United States
Department of
Agriculture

Forest Service

Engineering Staff

Washington, DC

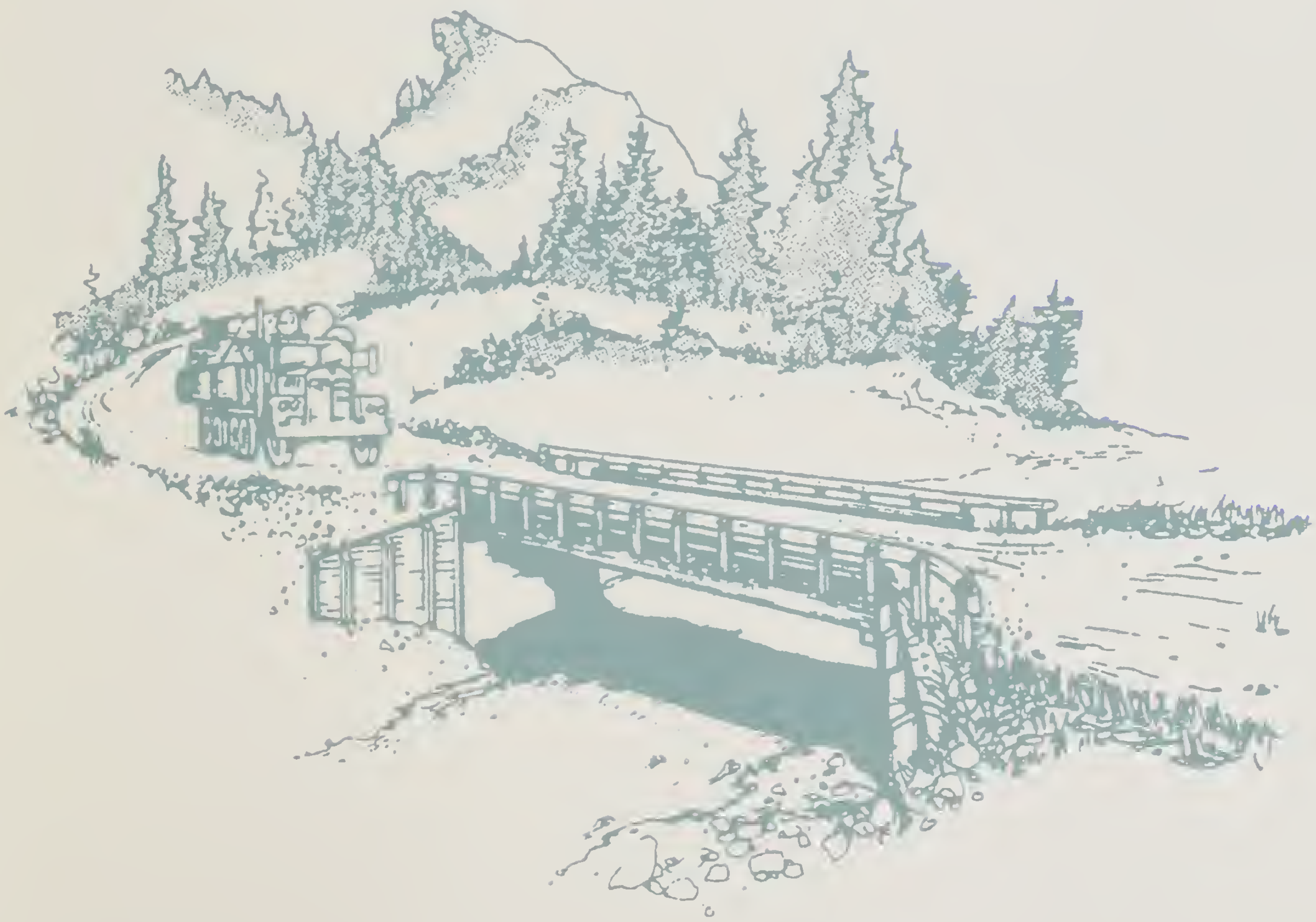
EM 7115-508-100

Revised
December 1999

Previous editions
obsolete

Bridges

Self-Study Training Course
Construction Certification Program



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Contents

Introduction

This self-study training course covers the field inspection activities necessary to ensure proper construction of bridges. As part of the Forest Service Construction Certification Program, the course is designed to train technical and professional employees in bridge inspection techniques and to prepare candidates to complete the written examination successfully.

The Construction Certification Program provides for the certification of engineering personnel based on training, experience, and performance (Certification of Personnel Engaged in Forest Service Construction Projects, FSM 7115). This training course was prepared to help applicants qualify for certification. Upon completion of other certification requirements, and upon recommendation of your Forest Engineer, you will be eligible to take the written examination covering bridges. The other certification requirements are given in the Construction Certification Handbook (FSH 7109.17).

Training Technique

This course has been designed for self-training. This means that:

(1) You can work alone.

(2) You can make as many mistakes as are necessary in learning the material—and correct them yourself.

(3) You can finish the training at your own speed.

You can keep this book for reference, so work neatly.

References

(1) *Forest Service Specifications for Construction of Roads and Bridges* (EM-7720-100LL), August 1996. Address: Landover Warehouse, 3222 Hubbard Road, Landover, MD 20785. To order, use Form No. AD–14. Phone: (301) 436-8450.

(2) *AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing*, Parts I & II, current edition, American Association of State Highway and Transportation Officials, P.O. Box 96716, Washington, DC 20090-6716. Phone: (800) 231-3473.

(3) *Standard Grading Rules for West Coast Lumber*, current edition; or *Grading Rules of the Southern Pine Inspection Bureau*, current edition. West Coast Lumber Inspection Bureau, 6980 SW Varns Road, P.O. Box 23145, Portland, OR 97281-3145. Phone: (503) 639-0651. Or Southern Pine Inspection Bureau, 4709 Scenic Hwy., Pensacola, FL 32504. Phone: (850) 434-2611.

(4) Bridge Welding Code, ANSI/AASHTO/AWS D1.5, current edition, American Welding Society, 550 NW LeJuene Rd., Miami, FL 33126. Phone: (305) 443-9353.

(5) *Sampling and Testing Self-Study Course* (EM-7115-509-100), current edition; USDA Forest Service Engineering Staff, Washington, DC.

(6) *Concrete Inspection Self-Study Course* (EM-7115-505-100), current edition; USDA Forest Service Engineering Staff, Washington, DC.

(7) *Construction Materials Sampling and Testing Guide* (EM-7720-5); USDA Forest Service Engineering Staff, Washington, DC.

(8) *Timber Bridge—Design, Construction, Inspection, and Maintenance* (EM-7700-8), June 1990; USDA Forest Service Engineering Staff, Washington, DC.

Individual Development Plan

The following is a sample Individual Development Plan.

USDA Forest Service

FS-6100-2 (4/79)

INDIVIDUAL DEVELOPMENT PLAN
(Reference FSM 6140)

1. Name (Last, First, Middle Initial)	2. Title	
3. Grade (Include Pay Plan and Series)	4. Unit	5. Fiscal Year

Section I - Present Position

a. Performance Skills Needed:

b. Development Planned:

c. Costs for Development Planned	d. Dates Planned	e. Dates Accomplished

Section II - Career Development

1. Describe next logical position (lateral or promotion):

2. Describe long range direction employee would like to pursue (specific function or identify a target position):

a. Performance Skills Needed:

b. Development Planned:

c. Costs for Development Planned:	d. Dates Planned:	e. Dates Accomplished:

The above plan meets mandatory training requirements and will enable the employee to meet current performance requirements.

Supervisor's Signature		Date	

The above plan will enable me to meet my performance responsibilities during this fiscal year.

Employee's Signature		Date	

Chapter 1
Contract Administration

Purpose

The purpose of this section is to clarify the specifications of a construction contract and to identify your inspection responsibilities. Inspection procedures for obtaining contractor conformance during bridge construction include (1) not interfering with the construction methods used by the contractor unless results do not conform to the specified quality; and (2) ensuring the uniform application of the specifications so that contractors can bid accurately and plan their construction operations efficiently.

Organization

The line of contracting authority is (1) the Secretary of Agriculture; (2) the Contracting Officer; (3) the Contracting Officer's Representative; and (4) the Inspector. As the Inspector, you should look to the Regional Office Specialist and Forest Engineer for assistance and technical advice and arrange with the Forest Engineer for personnel and equipment as needed. On such matters as fire prevention, activities outside the right-of-way, sanitation, and slash disposal, you should work closely with the District Ranger in whose district the project is located.

Responsibilities

As the Inspector, you will be responsible for ensuring that the bridge is constructed in accordance with drawings and specifications and that there is strict compliance with all provisions of the contract. To do this, you must become familiar with the terms and conditions of the contract and with the drawings and specifications. By the end of this course, you should be able to describe how to:

(1) Inspect materials and construction methods for quality and conformance with drawings and specifications.

(2) Measure, compute quantities, and prepare pay estimates for contractors.

(3) Check all dimensions on bridge drawings.

(4) Ensure that the contractor abides by the safety, sanitation, and fire regulations, especially the fish and game regulations for stream pollution, the Clean Water Act, and various "Best Management Practices" publications.

(5) Keep a diary as well as records and reports.

Procedures for Bridge Inspectors When Assigned to a New Project

When assigned to a new project, you should:

(1) Report to the Forest Supervisor, Forest Engineer, and the appropriate District Ranger.

(2) Study and become familiar with terms and conditions of the contract; drawings and specifications, including the addendum; and special project specifications. Check all dimensions to catch any errors or inadequacies in details on drawings so that corrections or additional detailed drawings or explanations can be prepared in advance of need; being prepared creates respect and harmony.

(3) Study and become familiar with previously completed subsurface investigations for abutments and piers; check all construction staking completed before bids are advertised. This includes one bench mark, the longitudinal centerline of the structure, and the centerline or layout line of all main bearings or abutments, wingwalls, and piers. For good control, check the accuracy of reference stakes and ensure that they are set sufficiently out of the construction area so as not to be disturbed; bridge layout stakes set by the Government allow contractors to set lines and grades with their own survey parties and instruments.

(4) Check whether profile and cross sections of the original ground of the abutments and piers are recorded correctly. Ensure that cross sections extend at least 3 meters in both directions from the excavation pay limits; these form the basis for calculating pay quantities for structure excavation. Take photographs of the complete bridge site and the original views of the ground at each abutment and pier; take additional photographs as the job progresses. During construction, take photographs of complex or different types of construction or equipment and of any conditions that might be a source of controversy.

Preconstruction Meeting Topics

During the preconstruction meeting, you should review contract provisions, drawings, and specifications needing clarification so that the contractor will understand fully what is expected. Discuss the work control requirements shown below.

(1) Location of source of aggregate and types of cement and admixtures. Contractor must send samples to a laboratory for testing and mix design at least 4 weeks in advance.

(2) Cutoff date for pay estimates.

(3) Designated Contractor's Representative, size of crew, and equipment required to do the job.

(4) Payrolls, minimum pay rates, special conditions, and rental of owner-operated equipment.

(5) Work schedule.

(6) Method of mixing concrete: transit-mix or batch plant on the job site.

(7) "Notice to Proceed Date." The contractor should receive this before any contract work begins on the project.

(8) Supplemental and Special Project Specifications.

(9) Shop drawing submittals.

First Day on Site Activities

With the contractor or designated representative, walk over the project site and show the contractor the centerline and layout line reference stakes, bench mark, and right-of-way limits. In addition, explain that the contractor shall incur the expense of replacing any destroyed or disturbed stakes. Ensure that sanitary facilities comply with State Health and Forest Service Health and Safety Codes on National Forest land.

As work progresses, ensure that barricades or *danger* or *warning* signs are set up to protect workers and the public.

Chapter 2
Bridge Construction Elements, Examples, and Problems

General

Several types of permanent bridges are built for the Forest Service Transportation System. In general, they can be divided into structures of reinforced concrete, structural steel, prestressed concrete, and timber. The type selected for a given site is based primarily on economics but also is subject to environmental and aesthetic considerations.

Cast-in-place reinforced concrete bridges are typically used for short spans. For clear spans from about 12,000 to 24,000 millimeters, the precast prestressed "I" girder superstructure is used with a cast-in-place deck. Because these bridges are cast in place, falsework must support the formwork during construction.

The welded plate girder is one of the most common types of structural steel bridge. Steel studs welded to the top flanges of these girders make the concrete deck and the steel girder a composite unit. This "composite action" permits the use of a much lighter steel girder than would be required if the steel studs were not used. The plate girders can be used to support the deck forms. Spans of 18,000 millimeters and up are used. Timber decks are also used.

Precast, prestressed girders, tee beams, and voided slabs are widely used. The members are built by a fabricator, hauled to the site by truck, and erected on the piers and abutments. A concrete wearing surface is sometimes cast in place on the precast members. Clear spans of more than 30,000 mm have been used. Precast, reinforced concrete three-sided box culverts are often placed on precast concrete footings in short span applications. Falsework is seldom required and construction is rapid.

Treated timber bridges are built with sawn stringers or glued-laminated stringers. Usually a timber deck is used. For sawn stringers, 10,000 millimeters is about the maximum practical length. Glued-laminated girders can be made up to about 25,000 millimeters in length.

The foundation used for a bridge depends on the foundation material at the site. Generally, bridge foundations can be divided into spread footings and pile foundations.

Spread footings are used to spread column or pier loads over a sufficient area of soil or rock to support the loads safely. A poor soil (soil with a low bearing capacity) therefore requires a larger footing than a good soil. Spread footings can be used on rock, sand, or gravel. Spread footings should not be built on materials of low bearing capacity, such as clay or silt.

When clay or silt are encountered or when scour depths are large, it is often necessary to use pile foundations. Piles transmit the foundation load to a deeper stratum having a higher bearing capacity. Treated timber piles are sometimes used on Forest Service bridges.

Clearing

Reinforced earth abutments are increasingly being used. Designate an area for disposal or burning. A permit from the District Ranger is required and shall be strictly enforced when debris is disposed of by burning.

Ensure that stumps and large cull logs that cannot be burned conveniently are placed out of sight downhill from road prism, at full contact with the ground, and out of major draws.

Remove to the outside of clearing limits any unstable trees and snags that could endanger the structure if they fell. The contractor can sell merchantable timber; however, it should be decked 250 millimeters top diameter, 3,000 millimeters long.

Bridge Stakeout

In general, the contractor will be required to perform the bridge staking. Check the specifications. If not, the staking procedure should be as follows:

Bridge Centerline, Reference Hubs, and Reference Targets

From the bridge drawings, locate the bridge centerline and pier and abutment layout lines and install reference hubs free of the work area for reestablishing critical points during construction. If topography permits, ensure that the tops of substructures are visible from at least one transit station. Reference targets are useful aids in reestablishing centerlines and layout lines.

Substructure Stations, Centerlines, and Reference Hubs

Accurately establishing a hub on centerlines at each substructure location is mandatory for taking original ground elevations for actual pay quantities. Ensure that reference hubs and targets for substructure layout lines are reasonably free from possible construction damage yet near enough for use during construction. Install reference targets if topography permits.

Bench Marks

Ensure that the project bench mark is near the work area but in a safe location. Check that it is protected from construction and that secondary bench marks are set closer to the work as needed, such as on concrete piers or abutments.

Note: Ensure that all level traverses are closed to originating bench mark; be sure field notes record such action.

Cross-Sections

Ensure that cross-sections are taken to record original ground elevations at each substructure location when required for estimating quantities. Take elevation of sufficient points to adequately describe ground.

Structure Excavation

Excavation is one of the most critical steps in bridge construction. Frequently, subsurface conditions are different from those shown on drawings. If necessary excavation goes deeper than 1,500 millimeters below plan elevation, a design change or change order is necessary and no further excavation work can start until the Contracting Officer approves. At the same time, notify the Regional Office bridge design section for new foundation design and approval. Record changes of elevation, dimension, and

description of strata. Strata used for footing should be approximately horizontal. When sloping bedrock occurs, ensure that the rock-bearing surface and footing is stepped, not sloped. Remove water from the foundation with sump holes outside the footing forms. If necessary, dewater the site with well points. Shoring or a cofferdam construction may be necessary to keep the banks from sloughing and to exclude water. Size should be sufficient to allow footing forms, sump holes, and clearance for batter piles. See example problems 1 to 3 and practice problems 1 and 2 on pages 2-3 through 2-5.

It is desirable to construct a foundation in the dry. If the cofferdam can be simply pumped dry, use this method; if not, use a concrete seal. If piles are to be used, drive them after excavation but before pouring any concrete seal. Seal concrete should be carefully placed under water with a tremie. The tremie tube should be charged with concrete to the hopper at all times. If any tremie loses its charge, lift it clear of the water and recharge it. Enough tremies should be provided to place the seal with a minimum of tremie recharging.

Soil conditions encountered during excavation for the footings sometimes make it necessary to change footing elevations from those shown on the drawings. When this must be done, check the bridge design because stresses in the structure often change. Refer information on any changed elevation to the Regional Office Engineering Staff, who will check field revisions.

Example problems 1 to 3 and practice problems 1 and 2 assume that Actual Quantity (AQ) is the method of measurement. If Design Quantity (DQ) is specified as the method of measurement in the contract, a pay quantity calculation is not needed unless there are ordered changes from the dimensions or elevations shown on the drawings. If changes in dimensions or elevations are ordered, ordered changes are provided for in subsection 106.04 of *Forest Service Specifications for Construction of Roads and Bridges*; calculate only the amount of quantity caused by the change unless a new price is negotiated for the total quantity, as in the case of an agreed-upon differing site condition.

Example Problem No. 1

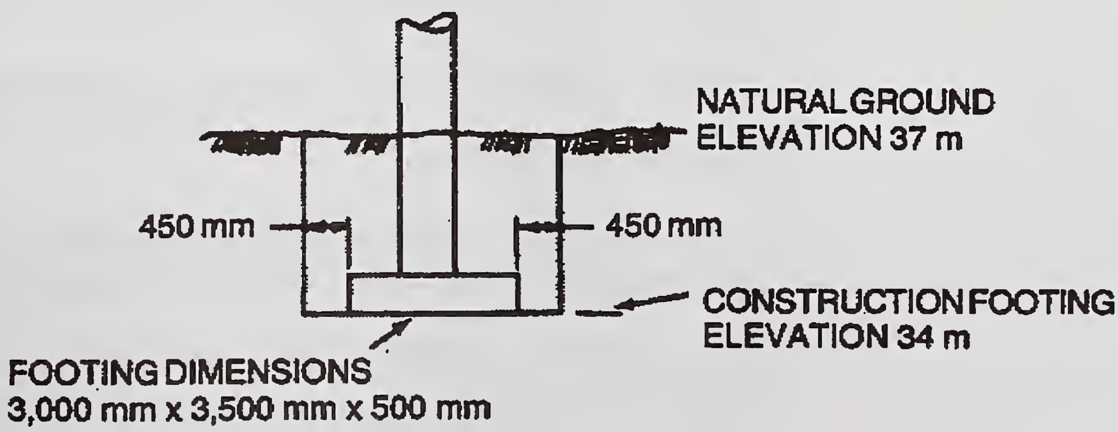

Figure 2–1. *Structure excavation*

Note: Elevations and stationing are in meters; structural components and excavations are dimensioned in millimeters.

Based on dimensions in figure 2-1, calculate pay quantities in AQ for structure excavation.

Solution:

$$\text{Pay Quantity} = \left(\frac{3000 + 900}{1000}\right) \times \left(\frac{3500 + 900}{1000}\right) \times (37 - 34) = 51.5\ \text{m}^3$$

Example Problem No. 2

Using the following information, calculate pay quantities in AQ for structure excavation.

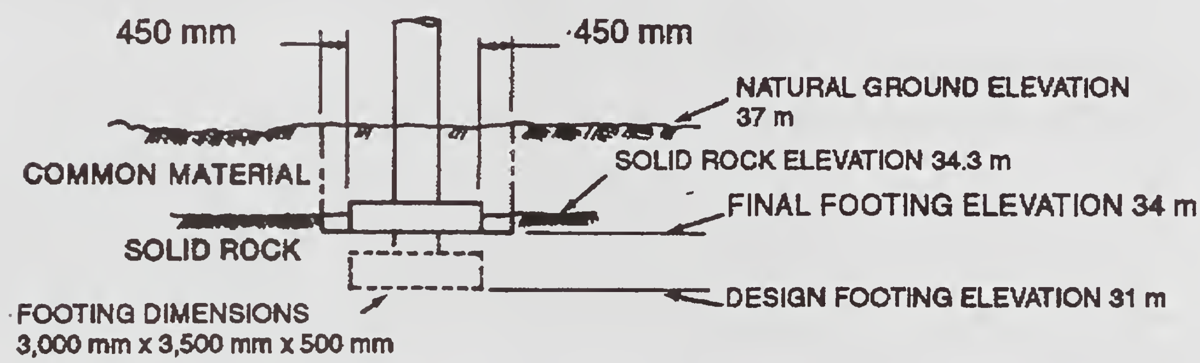

Figure 2–2. *Structure excavation*

Design was based on common material to elevation 31 meters. During excavation, solid rock was encountered at elevation 34.3 meters. In a conference with the Regional Office, it was decided to keep the footing the same size as designed but to raise the footing to elevation 34 meters, 0.3 meter into the rock.

Solution:

$$\text{Pay Quantity} = \left(\frac{3000 + 900}{1000}\right) \times \left(\frac{3500 + 900}{1000}\right) \times (37 - 34) = 51.5\ \text{m}^3$$

Note: Pay quantities for concrete and reinforcing steel also will change.

Example Problem No. 3

Calculate pay quantities in AQ, at the bid price and at the negotiated price, for the structure excavation shown in figure 2-3.

The footing was designed for elevation 33.5 meters. Acceptable bearing material was not reached until elevation 31 meters. Agreement was reached for a negotiated price below elevation 32 meters. The footing and column were redesigned by the Regional Office.

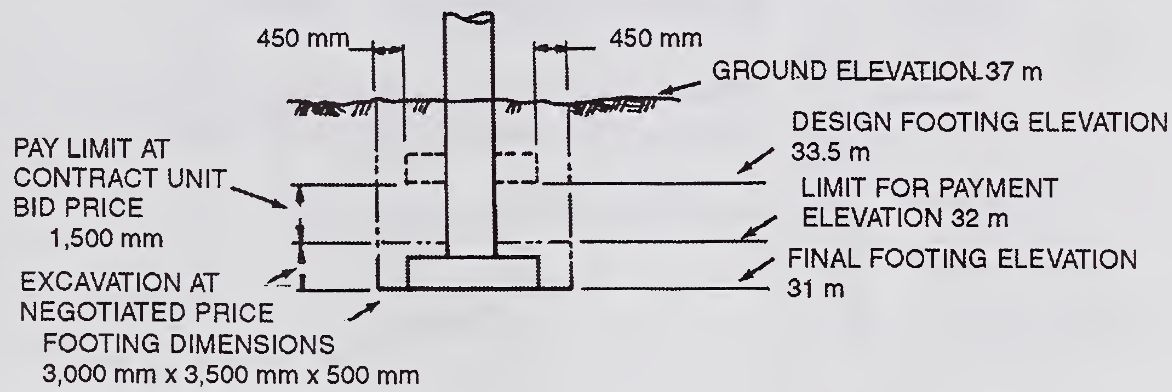

Figure 2-3. *Structure excavation*

Solution:

Pay quantities:

(1) At bid price $\left(\frac{3000+900}{1000}\right)\times\left(\frac{3500+900}{1000}\right)\times(37-32)=85.8\ \text{m}^3$

(2) At negotiated price $\left(\frac{3000+900}{1000}\right)\times\left(\frac{3500+900}{1000}\right)\times(32-31)=17.2\ \text{m}^3$

Note: Pay quantities for concrete and reinforcing steel will also change.

Practice Problem No. 1

Footing design was for gravel and boulders; however, solid rock was encountered at elevation 35 meters (1.5 meters above design elevation).

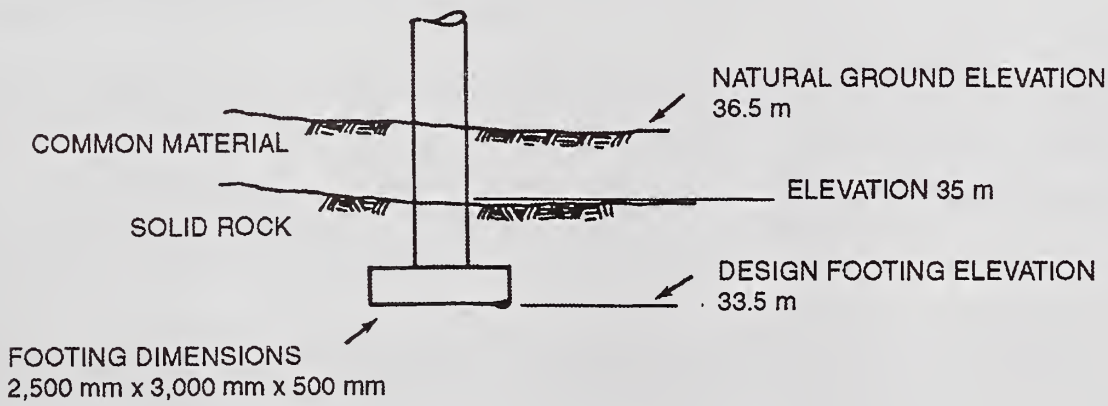

Figure 2-4. *Structure excavation*

What should the Inspector do? (see example problem no. 2)

Calculate pay quantity (assume AQ).

Practice Problem No. 2

The plans show that the footing was designed for solid rock; yet no rock was found at the design footing elevation.

What should the Inspector do?

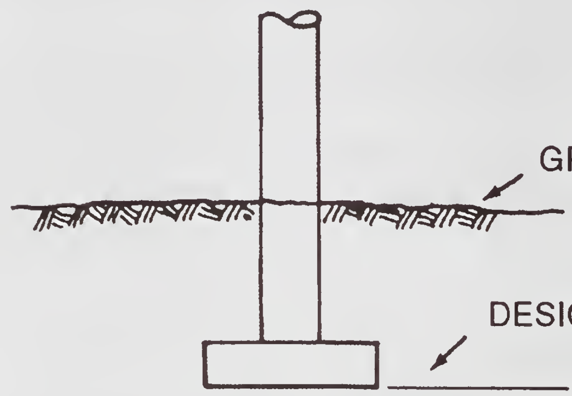

Figure 2–5. Structure excavation

Solution:

The Inspector should contact the bridge desgn engineer to determine if a new footing design is needed and how to proceed. A test hole may be needed to determine the depth of the rock and the new quantities for excavation that may be needed.

Pile Foundations

General

Piles transmit foundation load to a deeper soil stratum having a higher bearing capacity than that immediately below the footing. An increased bearing capacity is associated with a greater depth of load application. Often it is more economical to use piles to get down to good foundation material than to excavate deeply enough to use spread footings.

The bearing capacity of a pile is developed in two ways: end bearing and friction, as shown in figures 2-6 and 2-7. End-bearing pile is primarily a column that supports its load on top and bears on a firm stratum near its tip. Friction pile derives its capacity from skin friction between the soil and surface of the pile. Load is distributed over a large area.

In most cases, piles gain their capacity from a combination of point-bearing and skin friction over at least part of their length.

Pile-Driving Equipment

Leads. The leads consist of a framework or guide used to allow free travel of the hammer and to hold the pile accurately in the designated position. The leads are attached to the crane so that they can be held in a vertical or inclined position.

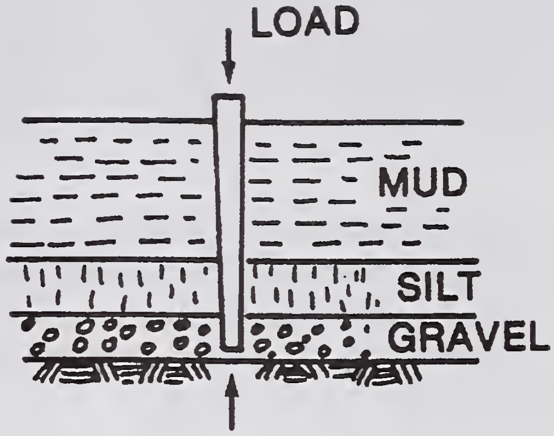

Figure 2–6. *End-bearing pile*

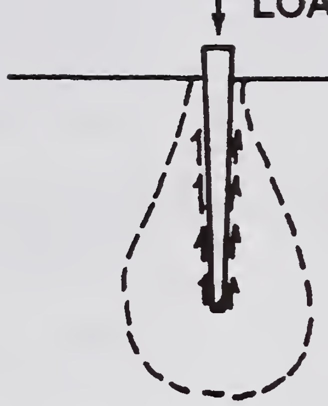

Figure 2–7. *Friction pile*

Hammers. There are five types of hammers. See FSS 551.03:

(1) *Gravity Hammer.* The gravity hammer is a weight that falls freely along the leads to the top of the pile. The minimum weight for a hammer is 900 kg; maximum is 1600 kg. Using too light a hammer is like trying to pound a survey stake with a tack hammer. An average drop is about 2.4 meters; a 4-meter drop is maximum. Using too great a drop damages the piling.

(2) *Single-Acting Steam or Air Hammer.* This is a unit with a ram lifted by steam or air pressure and allowed to fall on the pile by gravity. The commonly used rams weigh at least 1250 kilograms and fall about 0.9 meters. The contractor should furnish manufacturer's data for the type of hammer used.

(3) *Double-Acting Steam or Air Hammer.* In this hammer, steam or air pressure assists the ram's downward stroke in addition to gravitational pull. The contractor must furnish the manufacturer's energy rating for a given hammer.

(4) *Diesel Hammer.* This is a combination of gravity hammer and single-acting hammer. The fall of the hammer compresses and explodes diesel fuel in a cylinder similar to a piston, which drives the pile downward and, at the same time, lifts the hammer to the drop height. Energy delivered to the pile also includes the compression blow of the hammer.

(5) *Nonimpact Hammers.* Do not use nonimpact hammers, such as vibratory hammers, unless permitted in writing, shown on the drawings, or provided in the Special Project Specifications. If permitted, use such equipment for installing production piles only after the pile tip elevation, or embedment length, for safe support of the pile load is established by static or dynamic load testing. Control the installation of production piles when using vibratory hammers by power consumption, rate of penetration, specified tip elevation, or other acceptable methods that will ensure the required pile load capacity is obtained. On 1 out of every 10 piles driven, strike with an impact hammer of suitable energy to verify that the required pile capacity is obtained.

Jetting Piles. Jetting or spudding can be used to penetrate dense layers of sand or gravel. This loosens material near the pile and allows the pile to penetrate easily. When piling nears minimum penetration, jetting is stopped and piling is driven into undisturbed material for final bearing (figure 2-8).

Types of Piles. The following are types of piles used: untreated timber, treated timber, cast-in-place concrete, precast concrete, prestressed concrete, structural steel H-pile, and sheet piles. Untreated timber, treated timber, precast concrete, and structural steel H-piles are the types most commonly used on Forest Service bridges.

(1) *Untreated Timber.* Use these piles only where they will be completely and permanently below the water table; otherwise, they will decay. Take care not to overdrive. Use steel tips if required.

(2) *Treated Timber.* These piles split more easily than untreated timber; strap the butts before driving. Take care not to overdrive. Use steel tips if required.

(3) *Precast Concrete.* Handle these piles carefully and pick them up at designated points.

(4) *Structural Steel H-Piles.* These are the least susceptible to damage, but driving in boulders and rock can severely damage points. Use special tips if required.

Bearing Capacity of Piles

The bearing capacity for a pile is determined by using a test pile or by computing the load from the hammer data. Testing is the most exact method but is expensive. The drawings generally give the minimum bearing capacity and minimum pile penetration required. On most Forest Service jobs, bearing capacity is computed by using a pile driving formula. These

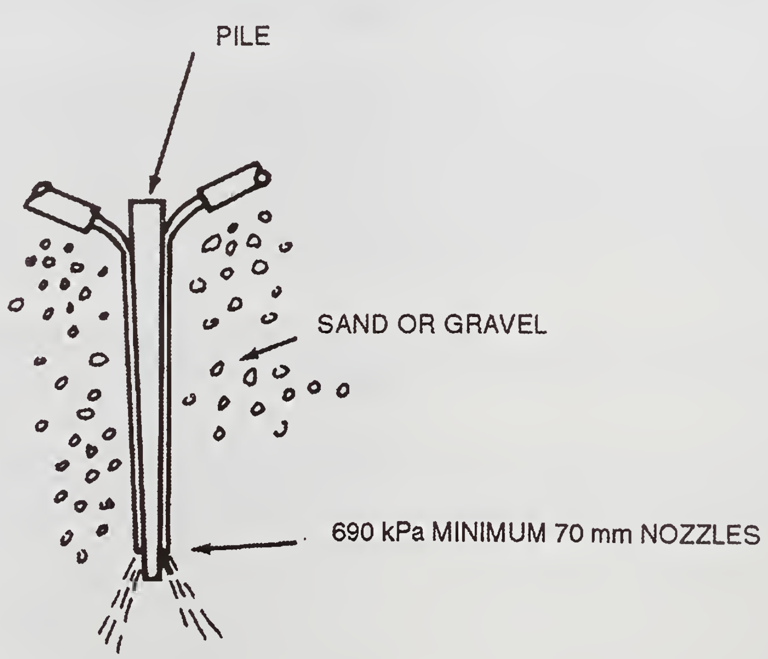

Figure 2–8. *Jetting pile*

formulas were developed by driving piles and testing them. As described in subsection 551.06(b) of the *Forest Service Specifications for Construction of Roads and Bridges*, the dynamic formula should be used unless the wave equation is required. Wave equation requirements are specified in subsection 551.03(b).

Dynamic Formula

Drive the piles to the penetration necessary to obtain the ultimate pile capacity in accordance with the following formula:

$$Ru = \left(7\sqrt{E}\ \log(10N)\right) - 550$$

Where

Ru	=	ultimate pile capacity in kN
E	=	manufacturer's rated hammer energy in J at the ram stroke observed or measured in the field
E	=	W x H x 9.81
W	=	mass kg of striking parts of hammer
H	=	meter height of fall of the ram measured during pile driving in the field
log(10N)	=	logarithm to the base 10 of the quantity 10 multiplied by N
N	=	number of hammer blows per 25 mm at final penetration

Solving for N:

$$N = 10^x$$

$$x = \left(\frac{Ru + 550}{7\sqrt{E}}\right) - 1$$

Factor of safety (*FS*) = 3.0

Test Piles

When recording test pile information, record the following:

(1) All pertinent data of hammer, type, weight, energy rating, and so forth (see section 551.06(b) of *Forest Service Specifications for Construction of Roads and Bridges*.

(2) Elevation of ground where pile is driven.

(3) Elevation of top of pile after it is driven.

(4) Pile identification.

(5) Compute by formula and record pile capacity at several increments as pile is driven. The following example problem demonstrates how test pile information should be recorded.

Example Problem No. 4

Given a gravity hammer of 1600 kg (W), with a drop of 3 m (H), determine whether the criteria for the Dynamic Formula are met according to sections 551.03(b) and 551.06(b)(3) of *Forest Service Specifications for Construction of Roads and Bridges.*

Solution for Pile No. 1, Pier No. 1.

Table 1. *Test pile data—penetration and pile capacity as function of depth when specified load tests shall be performed using the Dynamic or Static Methods described in section 551.12 of* Forest Service Specifications for Construction of Roads and Bridges.

Pile Depth (m)	***Average Penetration (mm per blow)***	***N Blows per 25 mm***	***Ru, Ultimate Pile Capacity (kN)***
3.0	54.6	0.46	457
4.5	41.1	0.61	643
6.0	41.1	0.61	643
7.5	27.9	0.90	899
8.0	21.6	1.16	1067
9.0	14.7	1.70	1319

Pile Foundations

Example Problem No. 5—Gravity Hammer (see figure 2–9)

Given: Gravity hammer of 1600 kg
Timber piles 9.1 m long
Drop: 3.0 m
Pile capacity: 177.93 kN

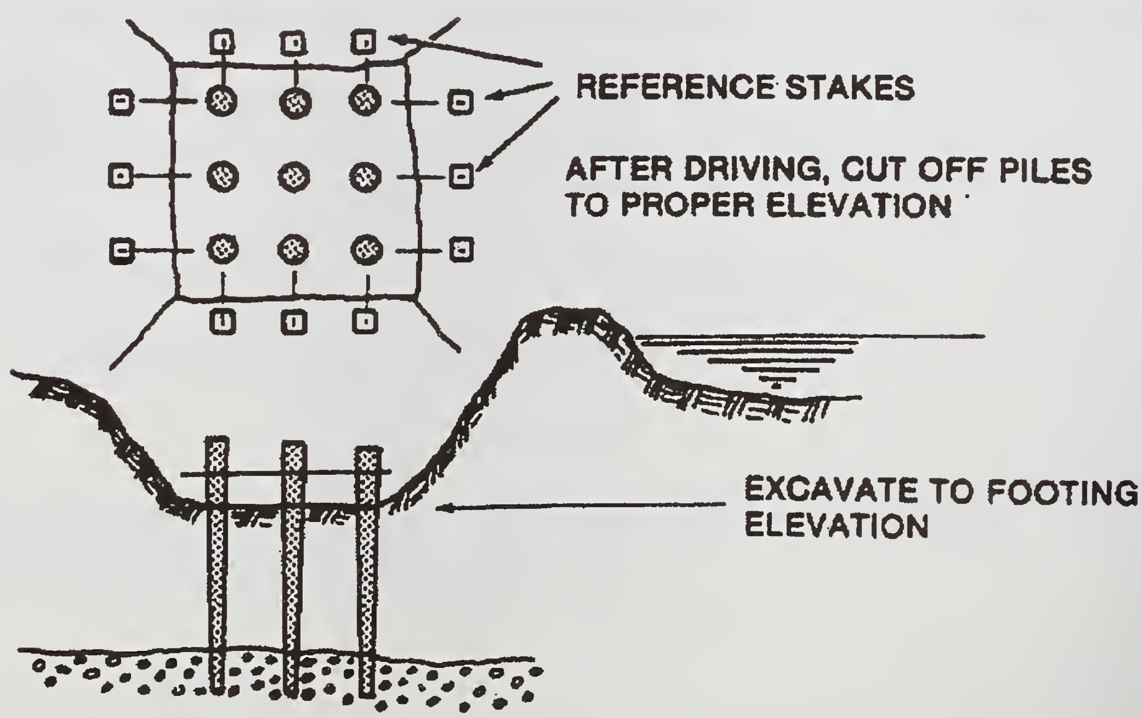

Figure 2–9. *Gravity hammer*

Determine whether the criteria for the Dynamic Formula according to sections 551.03(b) and 551.06(b)(3) of *Forest Service Specifications for Construction of Roads and Bridges* are met.

To measure penetration, make a mark on the lead and a mark on the pile at the same elevation; then measure the penetration after 5 to 10 blows, using the mark on the lead as a reference (table 2). Note that leads must be stable. If not, measure pile penetration with a level.

Solution for Pile No.1

Table 2. *Test pile data—number of blows and penetration at four locations*

Pile Depth (m)	***Number of Blows***	***Penetration (mm)***
4.5	10	267
6.0	10	203
7.0	5	89
8.0	5	70

Required: Check bearing capacity at the 4.5-meter depth with the Dynamic Formula,

$$Ru = \left(7\sqrt{E}\ \log(10N)\right) - 550$$

Where

Ru = ultimate pile capacity in kilonewtons (kN)

E = manufacturer's rated hammer energy in joules at the ram stroke observed or measured in the field

E = W x H x 9.81

W = mass kilograms of striking parts of hammer

H = meter height of fall of the ram measured during pile driving in the field

log(10N) = logarithm to the base 10 of the quantity 10 multiplied by N

N = number of hammer blows per 25 millimeters at final penetration

Solving for *Ru:*

$$\mathrm{Ru} = \left(\left(7\sqrt{\mathrm{E}}\right) \times \log(10\mathrm{N})\right) - 550$$

$$E = W \times H \times 9.81 = 1600 \times 3 \times 9.81 = 47{,}088$$

$$\sqrt{\mathrm{E}} = 217$$

at pile depth 4.5 m
10 blows gives 267 mm penetration
so 1 blow gives 26.7 mm penetration

$$N = \frac{25\text{ mm}}{26.7\text{ mm}} = 0.94\text{ blows / 25 mm}$$

$$10\,N = 9.4$$

$$\text{so } Ru = \left[\left(7\sqrt{47{,}088}\right)\left(\log\left(10 \times 0.94\right)\right)\right] - 550$$
$$= (7 \times 217 \times 0.973) - 550$$
$$Ru = 1478 - 550 = 928 \text{ kN}$$

To save time in the field in checking the bearing value, work out a table ahead of time using the formula, as shown in table 3.

Table 3. *Estimating bearing capacity—gravity hammer (Hammer Weight = 1,600 kg, Drop = 3 m)*

	Ru (kN)	
Penetration (mm)	***5 Blows***	***10 Blows***
250	–	967
225	–	1036
200	–	1114
175	–	1203
150	–	1305
125	967	–
100	1114	–
75	1305	–
50	1471	–
25	2027	–

Note: If first pile is forced up by the driving of a second pile, redrive until 177.93 kilonewtons capacity is reached. Do this as soon as possible, because the pile may become "set" if left too long.

Example Problem No. 6—Double-Acting Steam Hammer

Given: McKiernan-Terry Double-Acting 10-B-3 Hammer
Manufacturer's energy rating: 17,760 J
Treated timber piles 9.1 m long
Ultimate pile capacity: 800 kN

Determine whether the criteria for the Dynamic Formula according to sections 551.03(b) and 551.06(b)(3) of *Forest Service Specifications for Construction of Roads and Bridges* are met.

Solution for Pile No. 1.

Table 4. *Test pile data—number of blows and penetration at four locations*

Pile Depth (m)	***Number of Blows***	***Penetration (mm)***
3.0	20	584
6.0	20	432
7.0	20	356
8.0	10	140

Required: Check bearing capacity at the 3 meter depth using the Dynamic Formula.

Driving with the double-acting steam hammer is much faster than with a gravity hammer and does not allow much time for computing by formula. For estimating pile capacity, work out a table ahead of time using the formula, as shown in table 5.

Table 5. *Estimating bearing capacity—McKiernan-Terry double-acting hammer: energy rating 17,760 J*

	kN		
Penetration (mm)	**10 Blows**	**15 Blows**	**20 Blows**
400	–	–	475
350	–	–	528
300	–	475	591
275	–	510	623
250	–	547	664
225	–	591	708
200	475	639	755
175	528	691	810
150	591	755	890
100	755	916	–
75	870	–	–

Cofferdams and Seals

Cofferdams are normally constructed when excavating under water or when the excavation is affected by groundwater levels.

The contractor is to submit three copies of drawings and calculations 21 days prior to installation showing methods and construction details.

The cofferdam should extend below the bottom of the footing, be adequately braced, and as watertight as possible. Cofferdams should have sufficient clearance for forms and inspection and prevent erosion damage to the foundation. A foundation seal is constructed where the foundation area cannot be pumped reasonably free of water.

The water level should be maintained at the same level as the water outside the cofferdam while placing the seal concrete. The cofferdam should not be dewatered until the concrete strength is sufficient to withstand the hydrostatic pressure.

In foundations, streams, and other locations below a water table, It is sometimes necessary to place a concrete seal in the cofferdams to seal the foundation so that the cofferdam may be dewatered. Seal concrete usually is placed in the water by means of a tremie. The tremie pipe must be absolutely watertight at the joints, as well as at the connections to the hopper.

Before placing any concrete, seal the bottom of the tremie pipe with a plug. A 50-millimeter board slightly larger in diameter than the tremie pipe with

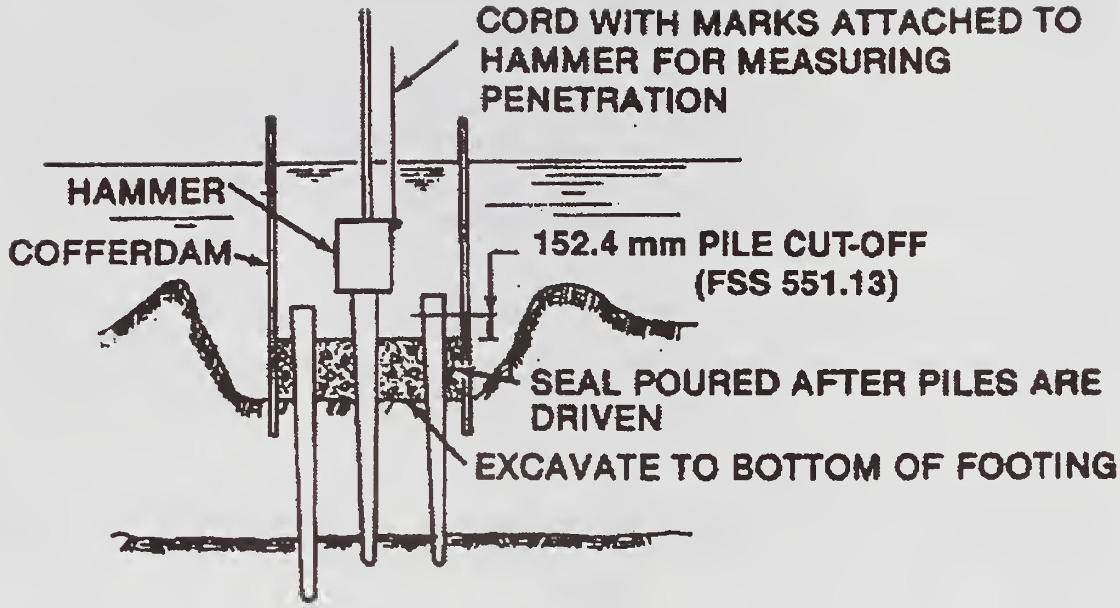

Figure 2–10. *Cofferdam*

a 20-millimeter round piece cut to the neat size of the inside of the pipe fastened to the top makes a satisfactory plug. Place a piece of cloth or burlap over the end of the pipe, and drive the plug in place. Lower the tremie until the plug rests on the bottom, then fill the tremie pipe with concrete. When the tremie is raised, the weight of the concrete will release the plug. The plug can be salvaged by fastening a piece of wire to it before lowering it into the water.

The thickness of seals is often based on the ratio of the water's density to that of the concrete. This ratio of 0.416 multiplied times the difference in water elevation between the inside and outside of the cofferdam gives the thickness for the seal. Seals in footings with piling require special design, and any changes must be referred to the Regional Engineer for approval. Compute seal thickness for the height of water at the time the concrete is placed, except if concrete is placed during a brief period of high water. In that case, compute seal thickness for ordinary water level and delay cofferdam dewatering until water has lowered to that stage. Do not calculate too closely; seals that are slightly too thick are better than seals that are not thick enough. See the two examples on pages 2-15 and 2-16.

Ensure that sheet piles are placed tightly together in cofferdams and that timber cribs are well caulked to prevent flow of water through the cofferdams while placing seal concrete.

Ensure that all equipment is in good working order before placing concrete in any seal. Permit no construction joints unless provided before pouring. Vertical joints are sometimes made, but only with approval of the Regional Office. Cofferdam struts and waling left in the seal concrete are not desirable, but sometimes it is necessary, especially in soft material, to have a set of struts and waling near the bottom of the sheet piling or crib. Concrete displaced by such struts and waling should not be deducted from the contractor's pay quantity.

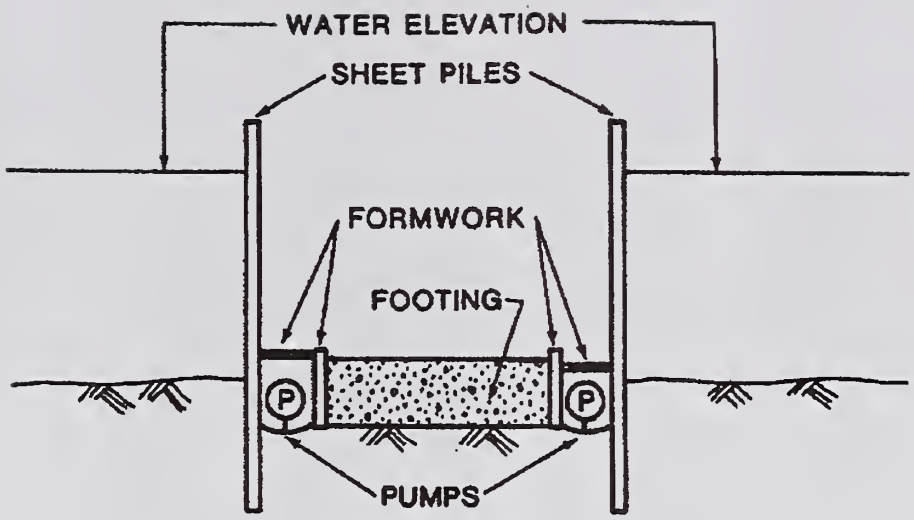

Figure 2–11. *Water flow between footing formwork and cofferdam wall.*

After the cofferdam is dewatered, all mud and sediment must be cleaned from the top surface of the seal before the footing is poured.

If the contractor can adequately pump the cofferdam clear of water and "boiling" the bottom of the cofferdam is *not* probable, the seal may be deleted. However, the contractor must provide clearance between the footing formwork and the cofferdam wall for *all* the water to run to the pumps without passing through the area to be occupied by the footing, as in figure 2-11.

Example Problem No. 7

Given: Water elevation and elevation of bottom of seal (see figure 2–12).

Find: Depth of seal.

$$h = 311\text{ m} - 306\text{ m} = 5\text{ m}$$

$$\begin{aligned}\text{Seal depth} &= 0.416 \times h \\ &= 0.416 \times 5\text{ m} \\ &= 2080\text{ mm}\end{aligned}$$

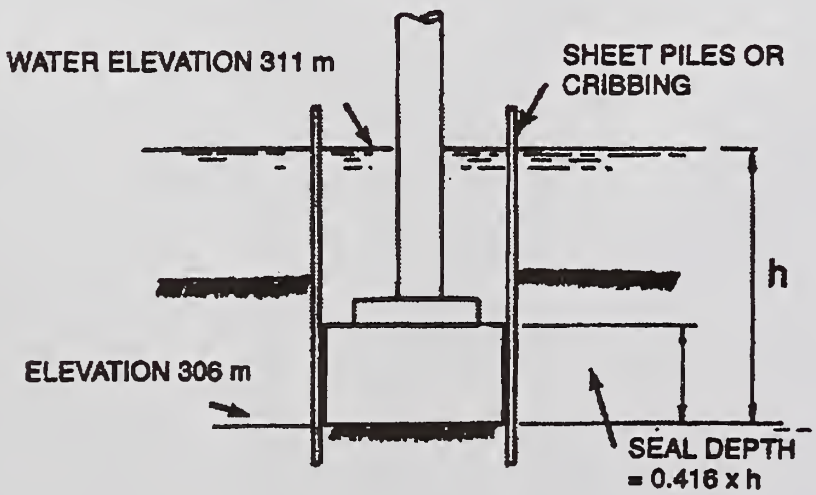

Figure 2–12. *Water elevation and elevation of bottom of seal*

Example Problem No. 8

Given: Water elevation and elevation of bottom footing (see figure 2-13).

Find: Depth of seal.

$$
\begin{aligned}
0.584 \times h &= 311\text{ m} - 307.5\text{ m} \\
&= 3.5\text{ m} \\
h &= \frac{3.5\text{ m}}{0.584} \\
&= 5933\text{ mm} \\
\text{Seal depth} &= 0.416 \times h \\
&= 0.416 \times 5993\text{ mm} \\
&= 2493\text{ mm}
\end{aligned}
$$

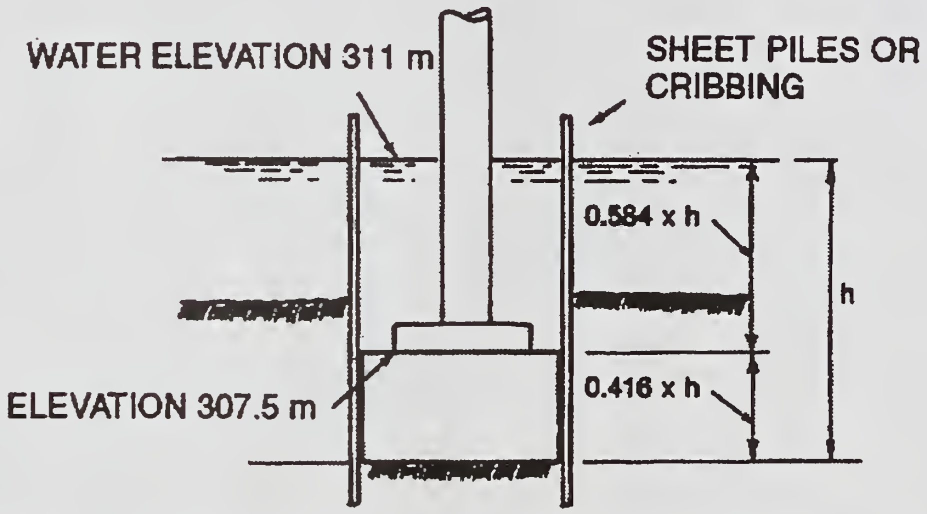

Figure 2–13. *Water elevation and elevation of bottom of footing*

Note: The above examples assume no loss of head (h) as the water passes under the bottom of the sheet piles. Generally, some reduction of h may be used. Reduction of h reduces the required seal thickness. The head loss is a function of the type of foundation material and the length of sheet pile penetration. Consult geotechnical handbooks as well as interpretation by Regional Geotechnical Engineers before making head-loss assumptions.

Treated Timber Substructures

Treated timber substructures frequently are installed directly on excavation surfaces, but treated timber piling can be used.

Bearing

It is difficult but essential to obtain an even-bearing surface on soil or rock. Backfilling with sand, finely crushed rock, or a concrete grout pad at the bearing elevation may be necessary.

Alignment

Sill alignment and elevation require accurate checking. Errors at this point result in difficult superstructure installation. Where possible, locate nuts and washers on the exposed side to allow for future tightening.

Anchorage

The tie-back anchors of treated timber do not require the degree of bearing quality demanded for sills. Excavate for anchor timbers and tierods with minimum disturbance of surrounding soil. Tamp backfill well or initial anchorage values will be lost. Use the same formula as for structure excavation.

If anchors are installed in fill sections and above original ground level, the Inspector should require the best possible tamping and compaction. Structure excavation in this case is not a measured pay quantity.

Structure Excavation

Footing and deadman anchor excavations are usually in the form of a trench. Payment is based on the 450 millimeter limit outside of the structures. For example, a 300 millimeter by 300 millimeter sill supporting 300 millimeter posts will justify a pay width of 1200 millimeter. If bulkhead planks are to be installed, add additional excavation thickness.

Glued-Laminated Decks

Often when metal dowels are used to connect glued-laminated deck panels together, some residual sawdust saturated with treatment will be found in the dowel holes, and some wood fibers will swell into the holes when treated. The contractor must remove such residue and "clean drill" the holes to the specified diameter (do not enlarge the holes) before installing the dowels to ensure proper dowel installation.

See also Forest Products Laboratory (FPL) Publication 263, *Erection Procedure for Glued-Laminated Timber Bridge Decks with Dowel Connectors*.

Treated Timber Certifications, Handling, and Stockpiling (FSS 557, Timber Structures)

You are responsible for furnishing the following compliance certificates to the Contracting Officer upon materials delivery at the job site:

(1) Grading and Dressing Rules—Timber Species.

(2) Treatment Certifications for penetration/incising, retention, and applicable treatment (for example, creosote, pentachlorophenol, and copper napthenate).

(3) Best Management Practices (BMP's) for treated wood in aquatic environments.

(4) Certifications for Structural Glued-Laminated Timber.

Ensure safe and protective handling methods are used to load, stack/store, and protect all timber and glued-laminated timber materials. Slings and protective devices must be used to inhibit damage to the protective envelope of treatment on all timber materials.

Measure and ensure the materials supplied are in compliance with dimensions and fabrications as shown on the drawings (timber and hardware).

Field treat any approved addition to the treated timber, for example, bolt holes that expose untreated wood.

Be familiar with FPL-263 erection procedures, match marking, and special assembly requirements.

Structural Steel

In most cases structural steel is fabricated before delivery. The Regional Office usually arranges for shop inspection. Your chief concern will be obtaining compliance with the specifications.

Identification of Structural Steel Shapes

Manuals published by the major steel companies or the American Institute of Steel Construction's (AISC's) *Steel Construction Manual* are excellent references for shapes, dimensions, weights, and so forth.

Stockpiling

Steel should be stockpiled on sills or other supports as arranged and in an orderly manner to make it easier to remove pieces needed for erection. Check each piece of material for size, length, and match marking. Carefully follow the fabricator's shop drawings.

Layout

Rigid tolerances in steel fabrication demand accurate layout of anchor bolts. Whenever possible, measure the anchor bolt layout and steel with the same tape before steel is erected.

Erection

Observation of good safety practices during steel erection is mandatory. Careless handling and poor rigging are major causes of accidents. Adverse weather conditions, inadequate staging, or lack of safety ropes or nets are hazards that should receive your attention. Common sense should govern your actions.

High-Strength Bolted Connections

The surfaces of parts connected by high-strength bolts must be free of dirt, paint, oil, loose scale, burrs, and other defects that would prevent solid seating of the parts. Check for correct bolt grip length for the total thickness of bolted materials. The general practice calls for one washer under the head or nut, depending on which end is torqued. For aesthetic purposes, nuts should be located on the side of the member that will not be visible from the traveled way, such as bolts through flanges to anchor glue-laminated deck panels, girder splice plates, and so on. Use calibrated impact wrenches or manually operated torque wrenches to obtain required torque; calibrate wrenches once a day. The turn-of-the-nut method, also an approved procedure, is as follows:

(1) Align holes with enough barrel pins or bolts to maintain dimension and plumbness.

(2) Install enough bolts to ensure that the parts of the joint are brought into full contact with each other.

(3) Use impact wrench to spin nut of each bolt to a snug condition (when wrench starts to impact).

(4) Install remaining bolts and tighten to snug fit.

(5) Tighten all bolts at least one-third turn, depending upon bolt length. See the specifications.

The compressor should not be located more than 50 meters from tools, and air pressure should be 700 to 750 kPa for 22-millimeter bolts and 750 to 900 kPa for larger bolts.

Any steel part to be embedded in concrete—such as the top of flanges, top of portal diaphragm, and undersides of sizing angles—should not be painted.

Holeburning should not be allowed as a substitute for drilling, nor should field welding, except as shown on the drawings.

Bearings

Check for warping or damage and accuracy of dimensions. The bridge seat should be free of all irregularities, level both ways, and at the correct elevation. Check sole plates for levelness and for full bearing when placed on top of a masonry plate or bearing pad. Do this with a straightedge or square before erecting steel. Also, the sole plate should be perpendicular to the web. Check bearing pad material for compliance.

Expansion Joints

Check the expansion device against drawings for warping and correct crown. Set the expansion joint such that the width of the opening corresponds to the ambient temperature. Set sliding plate joints so that plates are in contact and will not bind.

Poor Fabrication

Errors in fabrication frequently lead to on-the-job adjustments. The Inspector should accept conventional adjustments, such as reaming bolt or rivet holes. Prevent careless use of the cutting torch, welding equipment, or other methods that reduce the strength of the connection. When in doubt, check with the Regional Office.

Painting

Painting must conform to specifications. No painting should be permitted until you have investigated steel for absence of dirt, scale, and water.

Normally, steel is shop painted with a prime coat. Examine it for evidence of damage during handling and shipping. Consult the weather forecast before painting is scheduled. Ensure that paint is applied when surface temperature is between 10 °C and 40 °C.

Paint Application and Surface Preparation

Follow the following practices when preparing the surface and applying paint:

- Use practices in compliance with the manufacturer's safety data sheet and instructions.
- Apply paint by brush, roller, spray, or combinations thereof. Use sheepskin daubers, bottle brushes, or other acceptable methods for areas inaccessible by regular means.
- Cure each coat according to manufacturer's recommendations.
- Verify compatibility of proposed paint systems with existing systems.
- Where removal of existing paint systems is required, ensure environmental and safety procedures are in place. Hand and power tool cleaning methods and commercial blast cleaning may be used.
- Applications of paint coatings as recommended by the manufacturer shall be confirmed by measurement with proper paint thickness gauges.

- Refer to applicable paint system tables of the *Forest Service Specifications for Construction of Roads and Bridges* (section 563) for applications on galvanized surfaces, timber structures, concrete structures, and structural iron and steel structures.

- Use suitable means of protection for adjacent surfaces that are not to be painted.

- Prevent contamination of freshly painted surfaces.

Protection

At least 28 days before beginning surface preparation, a written plan must be submitted for approval. The plan should include details on protection of the environment, the public, adjacent property, and workers involved in the project.

Plan to include:

1. Manufacturer's data sheets
2. Containment plan
3. Disposal plan
4. Safety measures
5. Hazardous materials
6. A written plan for emergency spill procedures
7. Person responsible

Prestressed Concrete

Prestressed concrete is a simple beam (a beam supported at both ends) that, if loaded until it fails, pulls apart along the bottom and crushes along the top. In other words, the bottom fails in tension and the top fails in compression (figure 2-14).

Prestressing a beam puts an internal load on the beam in the opposite direction of the loads that will be put on the beam when it is in use in the structure. For a simple beam, the prestress load or prestress force creates

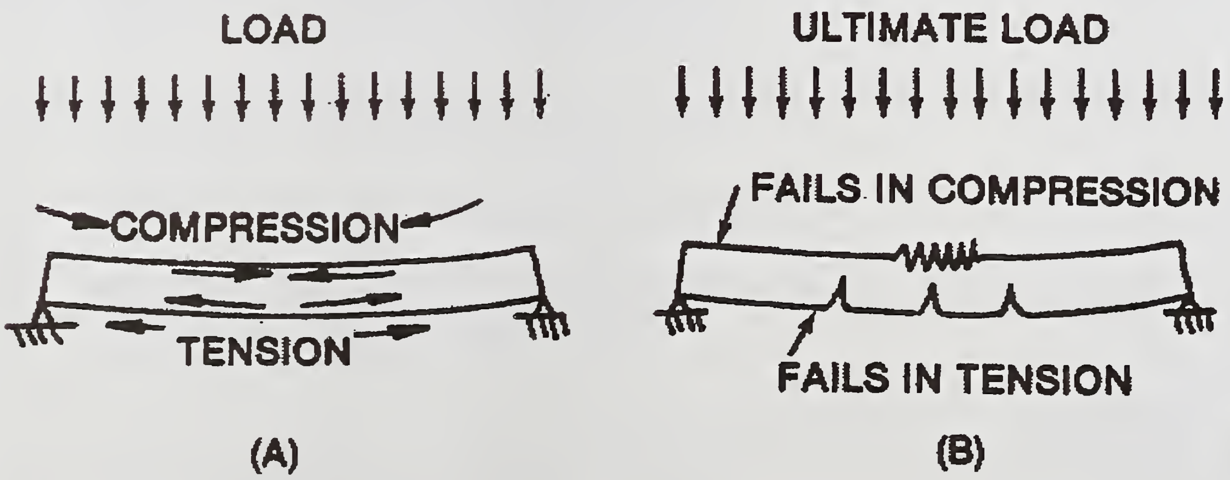

Figure 2–14. *Failure of a simple beam*

compression along the bottom of the beam and tension along the top, opposite to the stresses produced by the external loads.

One of the most common methods of prestressing is pretensioning, in which several high-strength steel strands are stretched to a high tension between two anchors and fastened (figure 2-15). The forms for the beams are built around the wires, and the concrete is poured into the forms (figure 2-16). When the concrete hardens, it "bonds" to the highly stressed strands. After the concrete has gained the required strength, the prestressed strands are cut from the anchors. The force in the wires is transferred to the beam, stressing it in the opposite direction to the stresses that will result from the loads put on the beam when it is in use (figure 2-17).

Prestressed beams also may be made by a post-tensioning process or a combination of pretensioning and post-tensioning. For the latter, ducts are cast in the beam, through which rods are threaded. The rods are then tensioned and the ducts are filled with grout.

Prestressed beams are usually built at fabricating plants where mass production techniques can be used. Prestressed beams are made in many different shapes, such as rectangular slabs, "T" beams, and "I" beams. As with steel, shop inspection is usually handled by the Regional Office. The beams are hauled by truck to the construction site and erected. During hauling and erection, great care must be taken in handling the beams because they have built-in loads. Tipping a beam over, twisting it, or picking it up at the wrong points may cause failure.

Figure 2–15. *High-strength steel strands with tension load*

Figure 2–16. *Concrete beam built around wires*

Figure 2–17. *Stressed beam after force is transferred from wires to beam*

Concrete Deck Construction

Concrete bridge construction Inspectors verify finished deck elevations. This is often done carelessly, leaving enduring evidence of haste, ignorance, or incompetence. Proper control of this work requires preparation, understanding of the basic structure and its parts, and careful field observation and computation; this care will yield a structure of true line and grade.

There are two types of concrete decks that present two different problems to the Inspector:

(1) *Prefabricated Decks.* These decks, set on wood, steel, or prestressed concrete girders, are brought onto the job site as complete structural units and set on the girders.

(2) *Cast-in-Place Decks.* These decks are cast in place on girders; they are cast in forms supported by falsework.

Prefabricated Girders

Girders are brought to the job site as complete structural units or subassemblies; these units are placed on the bridge seats with a crane.

Usually, camber is constructed into the girder to counteract dead load deflection caused by the weight of the girder, deck, curbs, and railing. The designer computes this camber to attain a line true to grade after the deck, curbs, and rails are in place and all formwork has been removed. If any variance from design camber is observed, corresponding adjustments must be made in the finished deck thickness. In all cases of this type, the Inspector should ensure that minimum deck thickness and dimensions of the structure are maintained, as established by the drawings.

The contractor's preparation for deck pours for these structures is similar in that the formwork is attached to the girder and does not require use of falsework extending to ground level. The formwork must be strong enough to support laborers, equipment runways, screeding equipment, loads of steel, and reinforced concrete without deflection or shifting. To obtain the proper finished deck elevations, the contractor sets guides, called screeds. These should be checked and verified by the Inspector.

Preliminary work for establishing and checking screed elevations is as follows:

(1) Confer with the contractor and review the screed plan and method of determining screed elevations. Note stationing along the centerline of girders of screed supports, usually 3.0 to 4.5 meters apart.

(2) From the dead load deflection diagram on the drawings, determine deflection at each station.

(3) Determine the minimum deck thickness allowed at these points and the vertical difference (minimum deck thickness plus deflection) (figure 2-18).

(4) After girders are erected, mark control points (stationing selected in part 1) on girder tops; determine the elevations of these points.

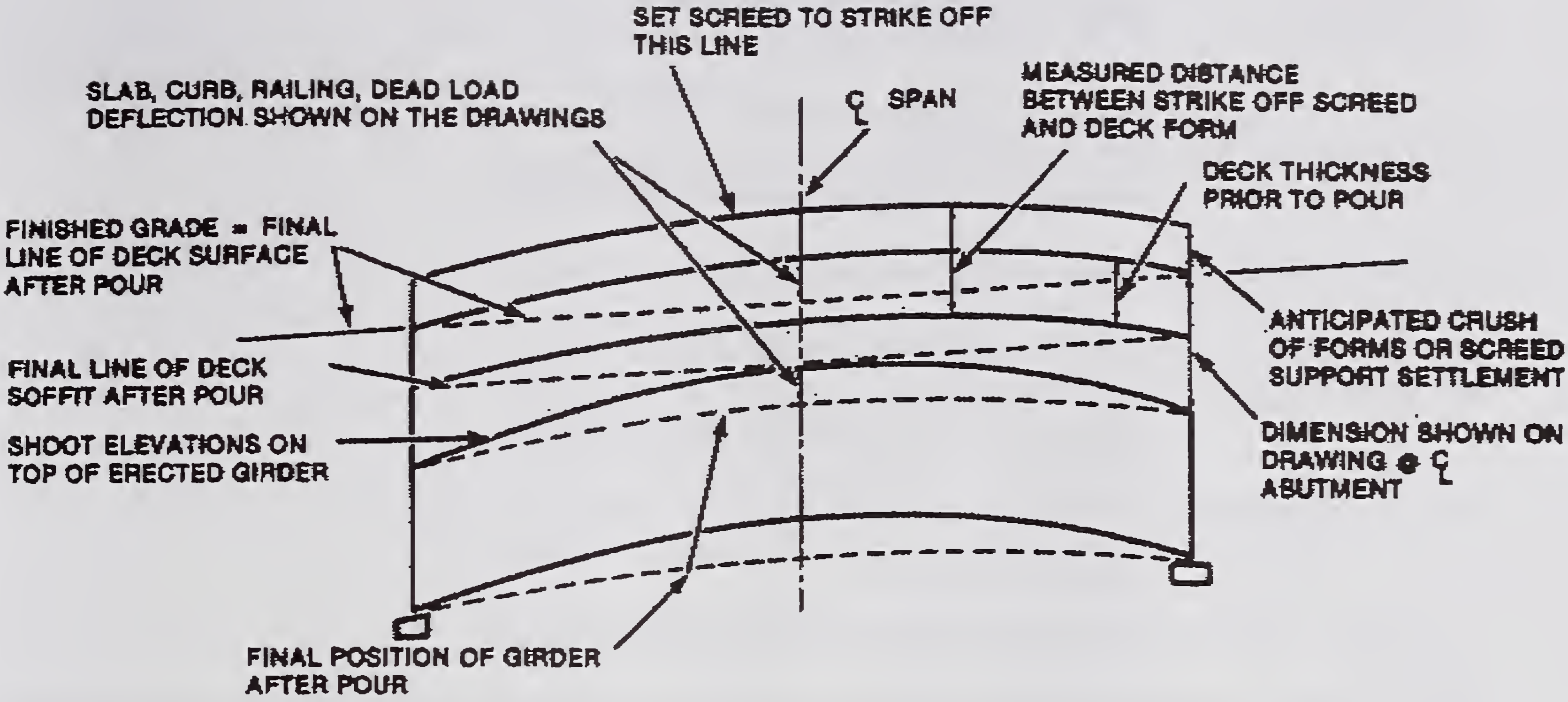

Figure 2-18. *Girder elevation*

After making these field observations, make further computation and checks that are necessary. These computations can be performed in the field, but office computation is preferable for accuracy and rechecking.

Deck finish computation procedure is as follows:

(1) From observed elevations, plot an elevation curve and determine whether curve is smooth and regular and coincides with camber specified on drawings. The drawings may show a dead load deflection curve and specify the camber to which the girders are fabricated, or they may show a camber curve. In any case, fabrication is usually not exact and actual girder camber deviates from the drawing curves. If not, correct the curve to attain a smooth curve, but never decrease the designed deck thickness.

(2) Develop a table showing the following for each screed point, 3 to 4.5 meters apart (table 6).

Compare calculated thickness to required thickness. If girders have been overcambered, the calculated thickness is less and the finished grade has to be raised to meet minimum deck thickness. If the calculated thicknesses are greater than the required thicknesses, the girders are probably undercambered or the bearing elevations may be low. If the latter, the roadway finished grade can be lowered, providing the deck thickness is within acceptable tolerances.

For the layout and check procedure for prefabricated girders, a time convenient to you and the contractor is selected, but it should be before the concrete pour and after formwork is in place. As the Inspector, you should:

Table 6. Screed point elevations

	Bearing	*3.0 m*	*6.0 m*
Theoretical elevation of finished deck surface at C_L of roadway			
Deduction for roadway crown or roadway slope			
Finished deck surface elevation			
Plus dead load deflection (due to slab, curbs, railing)			
Subtract elevations taken from smoothed curve plotted in "1" above			
Calculated deck thickness			
Change to millimeters			
Determine required deck thickness in millimeters			

(1) Check formwork to ensure that excessive settlement will not occur during pour.

(a) Check tightness of blocking.

(b) Verify that formwork is constructed according to approved drawings.

(2) Verify correct form measurements at checkpoints.

(3) Verify that screeds are properly set to give required deck thickness.

(4) Check expansion joint for correct opening.

During the pour, remain alert to any changes affecting the structure. Discontinue concrete placement and take corrective action if unanticipated events or settlements occur that cause a deviation of more than 10 millimeters from those shown on the drawings.

Cast-in-Place Girders

The entire superstructure is poured on falsework extending to the ground. Construction of formwork is discussed below.

A design dead-load deflection curve, normally shown on the drawings, is computed to attain a line true to grade after the superstructure has been poured and all falsework removed.

To counteract the dead-load deflection, camber must be built into the formwork as part of the falsework-formwork design and construction. Take extreme care that settlement of formwork does not occur during the initial pour for girders. Any anticipated settlement camber of falsework must be added to camber before pouring.

Checking for camber and setting screed elevations in a cast-in-place structure before pouring is similar to the procedure used for prefabricated girders, except that settlement of falsework must also be included. The procedure is as follows:

(1) Review drawings and determine stationing at ordinate points shown on the dead load deflection or camber diagram.

(2) Determine design elevations of girder bottoms at these same stations.

(3) Depending on plus or minus design camber, add or subtract camber ordinate and falsework settlement allowance to design elevations to determine girder soffit formwork elevations.

(4) Mark control points selected in the office along the bottom of each girder form. Determine actual elevations of these points.

(5) Adjust formwork to obtain elevations, as determined in step 3.

(6) To check for settlement of falsework after pouring of girders, select control points and determine elevations along top edge of the girder forms before any pouring, but after step 5.

Another quick method of checking is by a stringline between piers and along the outside of girder forms, with nails below strings at control points before pouring. Any formwork settlement would make nails pull away from the strings and indicate need for further checking.

After the girder pours and before pouring of the deck slab, the screed heights must be set accurately.

Follow procedures outlined under discussion of prefabricated girders.

Note: A rule of thumb is to allow 6 millimeters uniformly across span for anticipated form takeup and settlement of the falsework.

Formwork and Falsework

Formwork

Formwork must provide adequate support during concrete placement and until the concrete has gained sufficient strength to support its weight and any other loads that may be placed on it during the curing process.

The design and construction of the formwork are the responsibility of the contractor. The cost of formwork is usually 40 to 60 percent of the total cost of the concrete work in a structure. Inspect and measure formwork periodically during construction for correct size in dimensions, shape, alignment, elevation, and position so that any errors can be corrected before they become too difficult to change. Forms must also produce the desired surface appearance. Form ties, form anchors, form hangers, walers, and studs should follow the manufacturer's design and installation specifications.

Check bracing for strength, spacing, buckling, and bending. Diagonal bracings should be used to provide stiffness and prevent buckling of individual members. Check forms for chamfers and fillets at exposed corners, construction joints, or keys and weep holes.

Do not use studs and wales less than a nominal 50- by 100-millimeter S4S selected for straightness and graded for strength. All wales should consist of two members, and the joints in the top and bottom members should be staggered at least the distance between the form ties. Vertical kick strips should be used at the intersection of the wales at all external corners, and the corners should be tightly wedged and tied to prevent leakage. Under no condition should studs be spaced at more than 400 millimeters on center when used with 19-millimeter plywood or more than 300 millimeters on center when used with 16-millimeter plywood.

Spacing of studs should be reduced 30 percent for all thicknesses of plywood where the grain of the outer plies is parallel to the studs. Double horizontal wales should not be set more than 600 millimeters on centers and not more than 700 millimeters on centers when used with double 50- by 100-millimeter wales. With wood forms 3 meters or higher, double nominal 50- by 150- millimeter S4S vertical walers should be used and spaced not more than 3 meters on center, extending the full height of the forms and bolted or tied to every other horizontal wale to maintain the forms in straight and true alignment. Vertical joints of plywood should be plumb and located at centerline studs. Horizontal joints should be level and continuous.

Twisted wire ties should not be permitted. Form ties should be of such type to permit their removal to a depth of at least 25 millimeters from the face, without damaging the concrete. Ensure that pouring strips are level and placed whenever a pour must be stopped.

Falsework

Usually, the contractor is required to submit complete drawings for scaffolding, shoring, and footings (figures 2-19 and 2-20). This should be done well in advance so that drawings can be submitted to the Regional Office for approval before construction begins. Falsework can be supported on piles, wooden mud sills, or concrete footings. Mud sills should be used only on firm material unlikely to scour during use. The bearing capacity of the material must not change with a change in moisture content.

The contractor should compact foundation material before setting sill to preclude falsework settlement. You should have the contractor set gauging boards or telltales along the underside of cast-in-place concrete girders so that deflection and settling can be checked during pour. On long spans, jacks should be used, and on short spans, double wood wedges made of hardwood can be used to adjust for settling during concrete pour. Ensure that adjustment is made before initial concrete has set. Falsework is usually set 11 millimeters higher than plan elevation. Timber used in falsework should be sufficiently seasoned and of a grade and species suitable to support the loads. All shoring should be plumb.

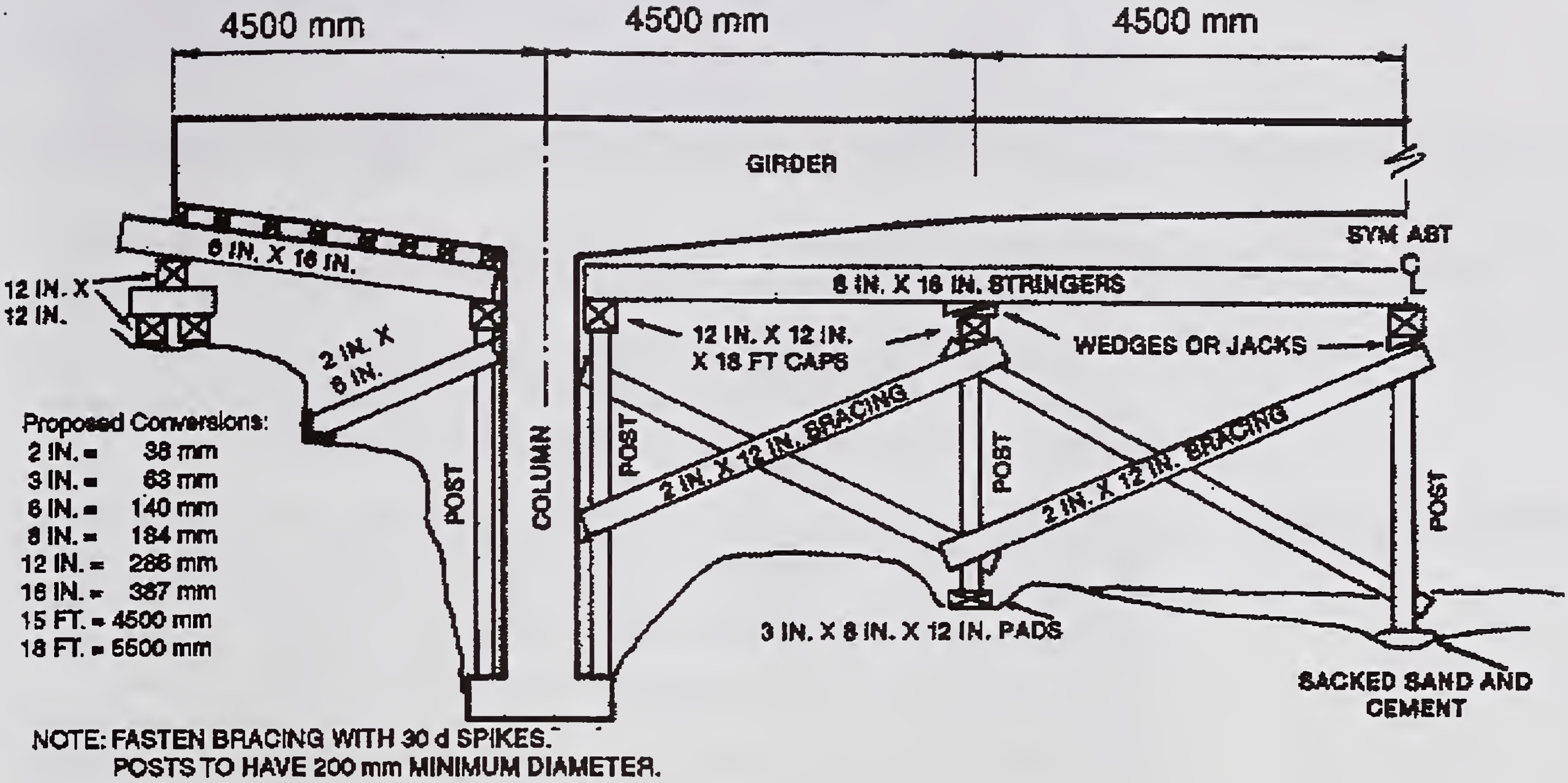

Figure 2–19. *Example Falsework Plan*

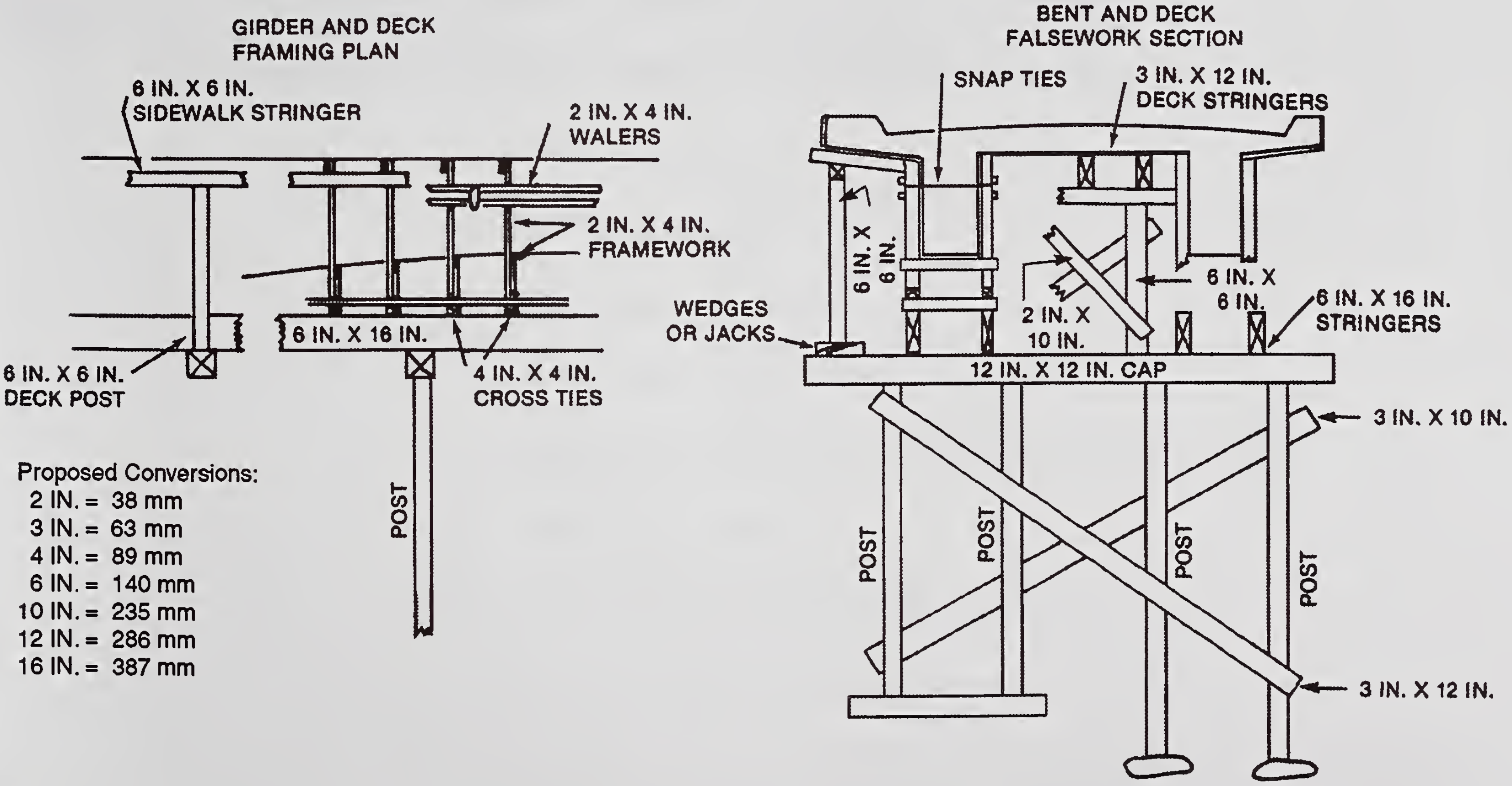

Figure 2–20. *Example Falsework Plan (framing plan and falsework section)*

Falsework Removal

Section 562.11, table 562-3, of the *Forest Service Specifications for Construction of Roads and Bridges* lists the minimum time that falsework must remain in place for different types of structures. The time ranges from 3 to 21 days, depending on the type of structure and cement. If concrete has cured at a temperature of less than 10 ·C, forms and falsework should not be released until strength has been determined and found acceptable.

Ensure that the substructure concrete has reached 28-day compressive strength prior to erecting the superstructure or additional bridge elements.

Do not release falsework in any continuous span until adjacent spans have reached the specified strength. Uniformly and gradually remove falsework beginning at center span and proceeding to the abutments.

Reinforcing Steel

Ensure that bars are free from rust, loose scale, grease, oil, or other coating that would tend to reduce bond. When reinforcing steel is delivered to the site, it should be placed off the ground on blocks. Check all bars for correct size, bending dimensions, and length. Correct the placement of reinforced steel regarding spacing, size, alignment, and clearance from form, and ensure that it is securely tied and anchored against probable displacement while pouring concrete. On slabs and girders, place enough correctly sized chairs or mortar blocks so that weight does not cause chairs to cut into the form. Bar supports should not be used to support runways for concrete placement equipment.

All reinforcing steel is marked at the mill to show mill designation, bar size, and type of steel. In addition, high-strength reinforcing steel carries a grade mark of 4 or 5 designating grade 400 or grade 500 bars. The yield strength of these bars is 420 and 520 MPa respectively (see Mekine Guide).

Chapter 3
Bibliography

In general, the examination questions are taken from the following material:

(1) Sections of the *Forest Service Specifications for Construction of Roads and Bridges* (FSS) EM-7720-100

(a) 206, Structural Excavation for Major Structures

(b) 206A, Structural Excavation for Minor Structures

(c) 551, Driven Piles

(d) 715, Piling

(e) 552, Structural Concrete

(f) 553, Prestressed Concrete

(g) 553A, Precast Concrete Structures

(h) 554, Reinforcing Steel

(i) 709, Reinforcing Steel and Wire Rope

(j) 555, Steel Structures

(k) 717, Structural Metal

(l) 556, Bridge Railing

(m) 557, Timber Structures

(n) 558, Prefabricated, Modular Bridge Superstructure

(o) 559, Log Bridges

(p) 716, Material for Timber Structures

(q) 617, Structural—Plate Structures

(2) Specifications from the American Association of State Highway and Transportation Officials (AASHTO), *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*—

(a) M–133, Preservatives and Pressure Treatment Process for Timber

(b) M–168, Wood Products

(3) *American-Wood Preservers' Association (AWPA) Standards*—

(a) C1

(b) C2

(c) C3

(d) C28

(4) Appropriate lumber grading rules—

(a) *Standard Grading Rules for West Coast Lumber*

(b) WWPA Grading Rules for Western Lumber

(c) *Standard Grading Rules for Southern Pine Lumber*

(5) Federal Acquisition Regulations (FAR)—

(a) Section 52.236–21, Specifications and Drawings for Construction

(b) Section 52.236–02, Differing Site Conditions

(c) Section 52.243–04, Changes

(d) Section 52.233–01, Disputes

Chapter 4
Important Points and Applicable Specifications

General

In general, you should be familiar with the following sections of the *Forest Service Specifications for Construction of Roads and Bridges* (FSS):

(1) 104—Maintenance for Traffic

(2) 106.04—Methods of Measurement

(3) 160—Quality Control and Quantity Measurement

(4) 202.02 and 202.03—Salvaging Material and Removing Material

Structure Excavation

Structure excavation specifications are included in the following sections of the *Forest Service Specifications for Construction of Roads and Bridges* (FSS):

(1) 206.03 and 201.02—Preparation for Structual Excavation and Clearing and Grubbing.

(2) 206.4, 206.12, and 206.13—The specifications detail Engineer's responsibility to determine proper elevation of bridge footings and payment provisions for excavation greater than 1.5 meters below planned elevation.

   (a) 1.5 meters or below the planned elevation, will be paid for as provided in a change order or design change; this price will generally be negotiated.

   (b) Less than 1.5 meters below the planned elevation, will be paid for at the price bid for structure excavation, unless there is an obvious changed condition (that is, a differing site condition), in which case, a negotiated change order or design change will specify the conditions of payment.

(3) 206.10 and 203.15—Layer thickness, material, and compaction requirements of backfill.

(4) 206.03, 206.09 and 206.12—Be familiar with limits of pay quantities for structure excavation (450 millimeters outside footing lines). Quantities based on ground elevations determined before excavating.

(5) 206.10, 206.12 and 206.13—Backfill is included in the price paid for excavation, unless a pay item for backfill appears in the schedule of items.

(6) 206.06—Cofferdam construction and design. (Study carefully all of this section and the previous reference material.)

   (a) 206.07—A foundation seal is required when ordered by the Engineer if the cofferdam cannot be pumped effectively. A tremie seal (seal concrete) must be placed against the cofferdam wall to seal the dam. The cofferdam should not be pumped until the seal concrete has gained sufficient strength, as the water pressure would damage the seal. Tremie seal concrete should always be placed underwater. Dewatering the sealed dam should not begin until the seal has set sufficiently to withstand the water pressure. The structural footing should never be placed against the side of the cofferdam, as the water inside the cofferdam cannot be removed during placement, and damage to the footing might occur.

   (b) The Engineer determines the thickness of the seal. The thickness is calculated by setting the weight of the concrete seal equal to the weight of the water displaced by the cofferdam and seal. This results in multiplication of the difference in elevation of water outside the dam and the bottom of the seal by 0.416 (ratio of water weight to the concrete seal weight) less any head loss.

   Example

Elevation of water outside dam	=30 m
Bottom of seal elevation	=26 m
Thickness of seal	=4m X 0.416
	=1.7 m

   (c) 206.06—Cofferdams (not necessarily sealed) should be used whenever strata below the water table are encountered above the bottom of footing elevation. Drawings of the proposed cofferdam should be submitted by the contractor when requested by the Engineer.

   (d) 206.13—Cofferdam and related construction may be included in the price paid for structure excavation, unless an item for cofferdam and related work is shown in the schedule of items. Note that the 1.5-meter excavation provisions apply to cofferdam construction. Design change and changed conditions provisions apply.

(7) 562.11 and 206.06—Removal of falsework in streams and cofferdam elements from the bridge site.

Piling

The following sections of the *Forest Service Specifications for Construction of Roads and Bridges* provide piling specifications (FSS):

(1) 551.05—Be familiar with the ordering requirements for piling.

(2) 551.06—Understand the use of pile-driving formulas, the effect of measurable hammer bounce on formulas, and the Four Conditions required for formula use, use of a follower, and so forth.

(3) 551.03—Method to compute maximum allowable bearing values of timber and concrete or steel piles.

(4) 551.13—Treatment of cutoff timber piles.

(5) 551.10—Approval of splicing of piles.

(6) 551.16 and 551.17—Measurement and payment for piling.

   (a) Two measurements generally are—

   - Length of piles furnished (meters).

   - Length of piles driven (meters).

   (b) Payment for splices is made only when approved by the Engineer unless a pay item exists in contract. Splices for the convenience of the contractor are not paid for unless approved by the Engineer.

   - Unit price each, when item is shown on schedule of items.

   - Agreed price on change order when no item is available in schedule of items.

(7) 551.03—The contractor must furnish the Engineer with manufacturer's specifications on pile hammer.

(8) 551.09—Allowable vertical and horizontal deviation of pile placement and minimum footing edge distance.

(9) 551.03—Be familiar with the following topics:

   (a) Gravity Hammers.

   (b) Open-End Diesel Hammers.

   (c) Closed-End Diesel Hammers.

   (d) Air or Steam Hammers.

   (e) Nonimpact Hammers.

(10) 551.03 and 551.06. You should be able to describe how to conduct a test to obtain data to compute the bearing value by the methods and formulas described:

   (a) Establish a datum that will not be affected by driving. The preferable method is to use a crosshair of a transit or level located such

that driving does not jar the instrument. Do not use a mark on the leads.

(b) Place a mark on the piling at the elevation of the datum.

(c) Mark the leads so that operator can determine proper height of fall, and height can be observed.

(d) Observe that the four conditions are met; that height of fall is correct during the driving; and that height is correlated with weight of the hammer.

(e) Measure pile penetration for 5 to 10 blows.

Before piling can be accepted, the following conditions must be met:

(a) Piling must be in proper location and within tolerances.

(b) Bearing must be obtained.

(c) Specifications in sections 551.03 and 551.05 of the *Forest Service Specifications for Construction of Roads and Bridges* minimum penetration (generally specified by Special Project Specifications determined by test pile) are met.

(d) No evidence of damage is found.

The primary disadvantages of driving piling with a drop hammer are:

(a) Slow driving rate.

(b) Danger of pile damage resulting from too high a drop.

Structural Concrete

Be familiar with the following sections of the *Forest Service Specifications for Construction of Roads and Bridges* related to structural concrete:

(1) 552—Be thoroughly familiar with mix adjustment, alternative aggregate size, approval of mix design, and cement content adjustmentsrequired from the contractor.

(2) 552.01—Air entrainment and slump requirements. See table 552–1.

(3) 552.10 and 552.04—Compressive strength tests; number of tests; procedure when tests fail.

(4) 552.06—Batching concrete.

(5) 552.10 and 552.11—Field adjustments to mix design. Contractor makes changes and Engineer approves.

(6) 552.08 and 552.09—Mixing and Delivery of concrete. Addiing water to retemper is prohibited.

(7) 552.12—Temperature and weather conditions.

(a) 552.12(a)— Cold weather.

- Heating aggregates and water.
- Providing protection to formwork.
- Liability for frost damage.

(b) 552.12(b)— Hot weather.

Be thoroughly familiar with section 562, Forms and Falsework. Several questions drawn from this section deal with falsework drawing reviews, use of metal ties, stay-in-place forms, and so forth. Cones are required when wire ties are used.

(8) 552.13— Handling and placing concrete.

(9) 552.13— Use of chutes.

(10) 552.14—Forming and constructing construction joints.

(11) 562.11— Removal of forms and falsework:

(a) Time limits.

(b) Responsibilities.

(12) 552.18— Concrete finishes:

(a) Ordinary Surface Finish (Class 1).

(b) Rubbed Finish (Class 2).

(c) Tooled Finish (Class 3).

- General float finish.
- Bridge deck finish.

(d) Sandblasted Finish (Class 4).

(e) Wire Brushed or Scrubbed Finish (Class 5).

(f) Color Finish (Class 6).

(13) 552.17— Curing concrete:

(a) Forms in Place Method.

(b) Water Method.

(c) Liquid Membrane Curing Compound Method.

Be familiar with setting screeds for deck pour. Assume forms are supported by steel or precast girders.

Refer to "Concrete Inspection"— Self-Study Training Course, Coust. Certif. Program, EM 7115-505-100 for information on additives and set retardants.

Prestressed Concrete

You should have a thorough understanding of the following sections of *Forest Service Specifications for Construction of Roads and Bridges* related to prestressed concrete:

(1) 553.05— Curing requirements for prestressed units.

(2) 553.08— Storing prestressed units.

(3) 553.12— Payment for prestressed units..

(4) 553— Approval of method, materials, and equipment required before stressing precast units.

Reinforcing Steel

For reinforcing steel specifications, be familiar with the following sections of the *Forest Service Specifications for Construction of Roads and Bridges:*

(1) 554.03—Furnishing reinforcing steel lists and bending diagrams.

(2) 554.09—Splices not shown on the drawings are not allowed without approval.

The grade of reinforcing steel can be determined by observation as follows:

(a) Grade 400 — Mark "4"

(b) Grade 500— Mark "5"

The following documents can be used to check the reinforcing steel quantity:

(a) Drawings.

(b) Bar lists and bending diagram furnished by the contractor, if approved.

Be familiar with reinforcing steel lump sum quantity (LSQ) and design quantity (DQ) pay item adjustments (see section106.04).

(a) If changes are not approved by the Engineer, no adjustment in quantity will be made.

(b) If a quantity change is approved by the Engineer, only the amount of change will be negotiated.

(3) 554.05— Bending of reinforcing steel.

Deck reinforcing steel is supported by metal supports or concrete blocks at no more than 1.2-meter intervals. Bar chair requirements are identified in section 554.08 of the *Forest Service Specifications for Construction of Roads and Bridges* and the Concrete Reinforcing Steel Institute's *Manual of Standard Practice.*

(4) 554.06— Do not use reinforcing steel that is cracked, laminated, or covered with dirt, rust, loose scale, paint, grease, oil, or other deleterious material.

Forest Service Specifications for Construction of Roads and Bridges does not specify the reinforcing steel grade; grade must be specified on the drawings. Generally, grade 400 is specifiecd for bridges. See sections 554.02 and 709.01 of the *Forest Service Specifications for Construction of Roads and Bridges.*

Structural Steel

Specifications that you should be familiar with related to structural steel are contained in the following sections of the *Forest Service Specifications for Construction of Roads and Bridges* and American National Standards Institute (ANSI), American Association of State Highway and Transportation Officeals (AASHTO), and American Welding Society (AWS) Bridge Welding Code Standards:

(1) 555.08— Shop assembly of girder.

(2) 555.17(4)—Calibrated wrench tightening.

(3) 555.17— Turn-of-nut method and snug tight condition specifications.

(4) 555.18— Bridge Welding Code—ANSI/AASHTO/AWS D1.5—Welder qualifications and prequalifications.

(5) AWS D1-1-75, D1.5— Percentage of shop and field welds subject to radiographic testing.

(6) 564— Ways for steel bearing plates to be set on abutments and piers.

(7) 563.02— Paint for each coat to be used shall be specified on the drawings or special project specifications.

(8) 555.14— Acceptable surface preparation for welding and where to look for type of surface cleaning.

(9) 555.08(f)— Field straightening of bent material.

(10) 555 and 563— Acceptable steel surface to which paint may be applied. Humidity and temperature requirements, and so forth.

(11) 555.08(f)— Bent shear connector studs should not have to be straightened, because some are bent for testing purposes.

High-strength bolts (AASHTO M164M or M253M) for bolted connections can be identified by a mark on the head, which shows the type of steel and the manufacturer.

Bolt and torque requirements for structural plate pipe and arches before backfill. Torque steel bolts to a minimum of 135 N•m and a maximum of 400 N•m. Torque aluminum and steel bolts on 2.5-millimeter-thick aluminum plates to a minimum of 120 N•m and a maximum of 155 N•m. On 3-millimeter-thick and heavier aluminum plates, to a minimum of 155 N•m and a maximum of 180 N•m.

To set a structural steel deck expansion device that calls for an opening of 40 millimeters at 15 °C, but the actual field temperature is 32 °C, calculate the actual expansion device opening assuming a 30-meter steel span fixed at one end and a coefficient of expansion of 0.0000117. Use the following formula:

Change in opening = L × T × expansion coefficient

where,

$$\begin{aligned}
L &= \text{length of span}\\
T &= \text{change in temperature}\\
\text{Change} &= 30\ \text{m} \times 17\ °\text{C} \times 0.0000117\\
&= 00597\ \text{m}\\
\text{Set opening} &= 40\ \ \text{mm} - 6\ \text{mm}\\
&= 34\ \text{mm}
\end{aligned}$$

Generally, expansion devices are used on concrete and steel bridges but not on timber bridges.

Timber Structures

You should have a thorough understanding of specifications for timber structures as described in the following sections of the *Forest Service Specifications for Construction of Roads and Bridges*:

(1) 557.04 and 716.03—Specifications for timber treatment-preservative type, retention, penetration (see also AASHTO M–133 and AWPA C1 and C2).

Timber specie, type of preservatives, retention, and penetration must be shown on the drawings. In general, preservatives will be specified, with creosote petroleum or pentachlorophenol in petroleum oil. The minimum retention and penetration shown in AWPA Standard C2 and BMP's as referenced in the specifications.

Note: water-borne preservatives are not recommended.

(2) 557.04 and .05—Requirements of field-drilled holes, cuts, and abrasion treatment, and plugging of unused field holes.

(3) FSS 557.02 and 716.01 and 716.03—Reinspection provisions of appropriate lumber grading rules (See AASHTO M–133).

Certificates of compliance for treated timber:

(a) Treatment.

- Type of treatment.
- Retention determined by assay.
- Penetration.

(b) Grade.

- Graded under which rules and paragraph number.
- Specie.

(c) Glued-laminated timber.

- Treatment.
- Grade.
- Section 557.02 of the *Forest Service Specifications for Construction of Roads and Bridges.*

Be able to properly calculate the number of board feet from bill of lumber details. *Do not deduct* fabrication or surfacing cuts from nominal dimensions in calculations.

Be able to define check, split, shake, and so forth. See definitions in appropriate grading rules booklet.

Be familiar with the following abbreviations:

WCLB—West Coast Lumber Bureau

S4S—Surface 4 sides

AITC—American Institute of Timber Construction

WWPA—Western Wood Products Association

AWPA—American Wood Preservers' Association

FSS 557.03 and 557.04 Storage of treated timber.

FSS 557.02, 716.02 and 557.08 Hardware to be galvanized.

The specifications for structural glued-laminated members are found in the U.S. Product Standard PS 56–73 (formerly U.S. Commercial Standard CS 253–63), AITC 117, and ANSI/AITC A 190.1.

Chapter 5
Job Performance Requirements

Each job performance requirement (JPR) is stated as a specific function to be performed. The key components following each JPR describe the action taken by the individual responsible for that function. The individual actions (key components) represent the essential knowledge needed for certification and provide the basis for written and oral examinations that allow the individual to demonstrate his or her capability at each level.

Documentation of activities and events on any project is considered a general and continuing requirement applicable to all JPR's. Reporting all significant occurrences and conditions is also considered a general and continuing requirement. Where documentation, recording, or reporting are a special consideration, pertinent instructions are provided in the key components under the appropriate JPR.

Groups of JPR's can be cited as a major activity on Form FS-6100-37, Performance Plan and Appraisal.

Bridges

Bridge construction operations are inspected for specification conformance and contract compliance. In general, the contract requirements are based on *Forest Service Specifications for Construction of Roads and Bridges*, EM 7720–100, August 1996, and contract clauses in the Federal Acquisition Regulations (FAR), part 52.

JPR 1

Prior to the prework conference and start of work, review the plans and specifications for content and completeness and become familiar with the supplements.

Key components of JPR 1 are the following:

(1) Points out errors or omissions in plans. Contractor responsible regarding fastener lengths for timber connections.

(2) Obtains corrective action before work starts.

(3) Identifies inspection needs at fabrication plants.

(4) Becomes familiar with all bridge pay items and required methods of measurement and payment.

(5) Checks contract requirements for extent of contractor's responsibility for quality control and quantity measurements.

(6) Makes note of contractor's responsibility for material's certification and shop drawings, including shop preassembly and match marking of deck panels with doweled connections.

JPR 2

Before notice to proceed is issued, field checks construction controls, surveys, and staking furnished by the Forest Service for adequacy and accuracy.

Key components of JPR 2 are the following:

(1) Identifies the staking requirements and supervises the staking within the intent of the specifications.

(2) Checks bridge centerline, including references to the nearest 3 millimeters.

(3) Checks the location of each pier or abutment and bridge ends, including references to the nearest 3 millimeters.

(4) Checks elevation stakes for bridge earthwork quantity measurements to the nearest 30 millimeters.

(5) Checks construction stakes for approach road fills to the nearest 30 millimeters.

(6) Checks stakes for borrow and waste areas and measurements to be used in final payments. Checks to the nearest 30 millimeters.

(7) Ensures that reference points are located far enough away to be safe from construction activities.

JPR 3

Checks provisions for traffic movement and control.

Key components of JPR 3 are the following:

(1) Determines whether construction signs will be adequate for safe movement of traffic through the construction area.

(2) If there are to be periods of road closure, ensures that notices and signs convey this message to the public.

(3) Checks temporary crossings for adequacy and safety.

JPR 4

Inspects the clearing, grubbing, and disposal for contract compliance.

Key components of JPR 4 are the following:

(1) Determines what the contact requires.

(2) Ensures that the designated clearing limit markings are established as required.

JPR 5

Ensures that stream-channel preservation and erosion-control measures conform to contract provisions.

Key components of JPR 5 are the following:

(1) Ensures that excavation is confined to those areas described in the plans. Any changes must be approved and documented by a contract modification.

(2) Does not allow the start of any work that would involve erosion or sedimentation until the contractor's water-pollution and soil-erosion plan and schedule have been accepted.

(3) Ensures that excavation material is not deposited in the stream channel.

(4) Inspects riprap and bank protection for correct placement.

JPR 6

Inspects the structure excavation and backfill operation and ensures that appropriate measurements are taken.

Key components of JPR 6 are the following:

(1) Obtains original ground elevation at each pier or abutment to the nearest 30 millimeters.

(2) Takes enough measurements to determine accurately the quantity of material excavated; documents this in construction field notes or construction diary.

(3) Obtains agreement with the contractor as to the original elevation before excavation is begun and documents this in construction field notes or construction diary.

(4) Obtains information needed for renegotiation when excavation greater than 1.5 meters below the elevation shown on the plans makes this action necessary.

(5) Instructs the contractor that backfilling cannot begin before the backfill material has been approved.

(6) Makes decisions as to backfill suitability.

(7) Ensures that backfill is placed and compacted in lifts as specified.

JPR 7

Inspects the construction of foundations for abutments and piers for contract compliance and construction adequacy.

Key components of JPR 7 are the following:

(1) Ascertains that the depth of excavation and character of the foundation material are acceptable before any footing or sill is installed.

(2) Checks the elevations of all bottoms of footings to the nearest 30 millimeters.

(3) If cofferdams are required, determines whether they can be pumped dry. If they cannot be pumped dry, an underwater concrete seal may be needed to obtain the desired dry condition.

(4) If a seal is required, determines the required thickness and discusses proper design and installation procedures with the contractor.

(5) Inspects all backfill for proper compaction according to the specifications.

JPR 8

Inspects the piles for specification compliance and proper installation.

Key components of JPR 8 are the following:

(1) Obtains contractors submittal on pile during equipment for review and approval.

(2) Inspects the piles for shape, taper, alignment, diameter, and allowable deviations therefrom.

(3) Checks timber pile certificate for proper treatment penetration, retention, and specie. Checks to ensure that required pile shoes are installed correctly.

(4) Before driving starts, checks the type and size of hammer and the height of fall of any gravity hammer to prevent damage to the pile. Checks hammer cushion.

(5) Obtains load tests as required by the specifications for diesel hammers requiring calibration.

(6) Checks pressure at the hammer as required by the manufacturer for all steam- or air-driven hammers.

(7) If required, has the contractor drive a test pile to determine the penetration needed to obtain the required bearing capacity.

(8) Verifies that the piles have attained the bearing capacity called for in the plans and specifications.

(9) Notifies the next level of authority if adequate depth penetration cannot be attained.

(10) Keeps an accurate log of all pile-driving operations, including spacing, length of pile in each line, number, penetration, and location of each splice. Records the cutoff length of the last section of each timber pile driven. Ensures that the tops of timber piles are properly treated and capped.

JPR 9

Obtains and reviews contractor's falsework plans before actual construction begins.

Key components of JPR 9 are the following:

(1) Inspects plans for adequate scaffolding, shoring, and foundation.

(2) Discusses with the contractor any apparent deficiencies. Documents these discussions in writing, including discussions about form removal

schedules and contractor's responsibilities for accuracy of the falsework plans.

JPR 10

Discusses form layout and detailing with the contractor before forming is started. During construction, inspects to see that each forming segment is completed in accordance with the requirements of the details on the plans and specifications.

Key components of JPR 10 are the following:

(1) Inspects the forms for cleanliness, tightness, and correct bracing.

(2) Inspects the forms during each segment of the work so that any problems can be corrected as they occur.

(3) Inspects the forms for proper form ties.

JPR 11

Checks and inventories all reinforcing steel at the time of delivery. Checks the placement of all reinforcing steel prior to the concrete pour.

Key components of JPR 11 are the following:

(1) Checks delivered reinforcement against the lists and bending diagrams for proper grade, quantity, and size of material.

(2) Verifies that bars are bent according to standard detail and that splices are correct and made in the planned locations.

(3) Verifies that bars are clean and free of encrustations of rust, mud, concrete, or other deleterious material.

(4) Ensures that proper minimum concrete cover over the bars is maintained. This includes the ends of the bars.

(5) Verifies that adequate supports are used to keep bars from being forced out of position during concrete pours.

(6) Ascertains that the right size bar is placed in the right location. Ensures that bar size changes in a line of reinforcement are made at the specified locations.

(7) Tops of stirrups are frequently bent out of position when placing concrete in the beam forms. When the contractor straightens out these bars, ensures that they are not bent back into position without there being a block of wood or other support next to the stirrup at the point of embedment. If support is not provided, the bond between stirrup and concrete might break.

(8) Verifies that heat is not applied to make field bends in reinforcement bars.

(9) Does not allow the contractor to order vertical reinforcement of columns and retaining walls until after the excavation for footings has been

completed and approved. This will forestall possible improper splicing of these main reinforcement bars should the final footing elevations be deeper than shown on the plans.

(10) Ensures that there is no welding of reinforcement unless specifically called for in the plans.

(11) Ensures that there is no splicing of reinforcement bars, unless it is allowed in the plans.

JPR 12

Ensures quality assurance of the concrete used in the bridge.

JPR 13

Inspects concrete for proper finishing and curing. Verifies contractor's knowledge of rubbed finishes.

Key components of JPR 13 are the following:

(1) Inspects finishing operation for specification compliance.

(2) Ensures that curing is begun immediately after placing and is continued for the period described in the specification.

(3) Ensures proper curing method is used for each concrete element.

(4) Ensures specified curing period has been met.

JPR 14

Inspects erection of structural steel supporting members and the floor systems.

Key components of JPR 14 are the following:

(1) Obtains from the contractor complete shop drawings showing fabrication and erection methods.

(2) Obtains mill order certificates for all structural steel.

(3) Visually inspects all steel for conformity.

(4) Obtains assistance from the bridge engineer, when needed, to ensure steel members have been fabricated in accordance with approved shop drawings.

(5) Inspects camber of steel girders or beams.

(6) Inspects all dimensions, paying particular attention to the thickness of flanges and webs.

(7) Ensures that all welds are checked by a qualified expert in that field.

(8) Checks all bolt holes and field connections for accuracy.

(9) Inspects field painting operations for paint type, surface preparation, application, thickness of coats, and proper atmospheric conditions.

JPR 15 Inspects construction of structural concrete supporting members and floor systems.

Key components of JPR 15 are the following:

(1) Obtains shop drawing for precast members.

(2) Checks camber of precast concrete girders or beams.

(3) Inspects the screed settings for the deck pour for accuracy and adequacy.

(4) Informs the contractor of the specified minimum period that must elapse before removal of the falsework and forms.

(5) Checks falsework against approved drawings (JPR 9).

(6) Discusses with the contractor the removal of falsework in streams and cofferdam elements from the bridge site.

JPR 16 Inspects construction of glued-laminated supporting members, wood floor systems, and other timber members.

Key components of JPR 16 are the following:

(1) Obtains shop drawings for glued-laminated members and other timber members required in drawings and specifications.

(2) Inspects treated members to ensure that the treatment process caused no excessive splits or checks and checks certificates to ensure that proper penetration and retention of the preservative have been achieved. Ensures that field treatment of field-drilled holes is properly completed.

(3) Verifies that all sawn timber and all glued-laminated members have been incised in accordance with the provision of the contract.

(4) Checks all treated timber to ensure that no holes have been made through the treated wood into the untreated material.

(5) Obtains all compliance certifications required by the specifications when the material is delivered to the job site. Certifications should include the following:

   (a) Verification of compliance with grading rules and species of timber, lumber, and piling.

   (b) Verification of treatment, including type of preservation, retention in kilograms per cubic meter, and penetration in millimeters.

   (c) Verification that all glued-laminated structural members have been marked with an AITC quality mark. An AITC certificate of compliance shall also be provided to certify conformance with ANSI/AITC 190.1(83), formerly PS 56.

(d) Ensures compliance with *Best Management Practices for the Use of Treated Wood in Aquatic Environments* (current edition); and other BMP publications.

(6) Inspects timber using reinspection provisions of appropriate grading rules.

JPR 17

Inspects the construction of bridge decks for specification compliance.

Key components of JPR 17 are the following:

(1) Ensures that the contractor is familiar with FPL Publication 263, "Erection Procedure for Glued-laminated Timber Bridge Decks with Dowel Connectors," when needed.

(2) Inspects plank and laminated floors for construction according to plans and specifications.

(3) Checks all falsework and wedges prior to placing concrete.

(4) Checks to ensure that settlement and deflection of the concrete bridge deck are within tolerance.

(5) Discusses with the contractor the proper setting of screeds or headers to bring the surface of the bridge deck to required grade. Considers camber, deflection, and anticipated settlement.

(6) Inspects approach railing, guardpost, hazard markers, and curbs for true line and grade.

(7) Ensures that all bituminous wearing surface is mixed and placed according to the specifications.

JPR 18

Ensures quality control of concrete used in substructures of bridges.

Key components of JPR 18 are the following:

(1) Checks for correct class of concrete, depending on use in the structure.

(2) Obtains mix design for the concrete and prepares to make field adjustments if necessary. Checks the moisture content of the aggregate and ensures that aggregate meets specifications before approving use in the design mix.

(3) Checks specifications for requirements of contractor quality control and ensures that adequate tests are made on the concrete.

(4) Ensures that the concrete is mixed at or very close to the job site and that placement is completed within specified time limits.

(5) Ensures that forms and reinforcing steel are watered immediately before placing concrete.

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